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14. ABSTRACT The US Marine Corps currently gives Marines six months following their 42-day postpartum convalescent leave, or about seven and a half months, to rehabilitate before resuming fitness testing. However, this time period is inadequate to regain sufficient muscular strength and endurance in the transversus abdominis and pelvic floor muscles to enable safe fitness testing due to the high-impact and/or high-intensity of the constituent test events and the sustained repetitive nature of the abdominal crunch event. Pregnancy-induced musculoskeletal changes, to include hormone-induced ligament relaxation, persist for months after childbirth and have substantial ramifications for abdominal and pelvic floor muscles. If postpartum women do not return in a graduated, progressive manner to high-impact activities and activities that increase intra-abdominal pressure, such as trunk flexion and heavy lifting, they are more prone to incidence or recurrence of diastasis recti, abdominal fascia herniation, incontinence, and/or pelvic organ prolapse, all of which affect long-term health and readiness. The current timeline for resuming fitness testing should be extended to no earlier than 9 months postpartum. Additionally, postpartum Marines should be referred to physical therapy programmatically so that they can undergo rehabilitation following childbirth with a physical therapist who has women's health training and experience.					
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MASTER OF MILITARY STUDIES


**Things Don't Just Go Back to Normal:
The Implications of Antenatal and Postpartum Physiology and Morphology for the
Resumption of Fitness Testing**

SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF MILITARY STUDIES

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Executive Summary

Title: Things Don't Just Go Back to Normal: The Implications of Antenatal and Postpartum Physiology and Morphology for the Resumption of Fitness Testing

Author: Major Katharine E. Carlson, United States Marine Corps

Thesis: Current US Marine Corps policy regarding postpartum fitness testing does not afford Marines sufficient time to recover properly or provide appropriate training resources to facilitate return to full duty activities prior to resuming fitness testing.

Discussion: Pregnancy induces a number of physiological and morphological changes, including hematological, cardiovascular, respiratory, and musculoskeletal changes, as well as changes to other systems within the body. While beginning or maintaining at least a moderate exercise program during the antenatal period maintains or improves postpartum cardiovascular fitness, musculoskeletal changes, to include hormone-induced ligament relaxation, persist after childbirth and have substantial ramifications for abdominal and pelvic floor muscles. Abdominal muscle changes, which persist even at 6 months postpartum, correlate with abdominal functional deficits, and ligament relaxation makes the pelvic floor more prone to damage. Microtrauma of pregnancy from the increased weight of the fetus and following childbirth due to non-optimal strategies for transferring loads through the pelvis and macrotrauma sustained during second stage labor and vaginal delivery can cause pelvic floor dysfunction. Abdominal and pelvic floor changes affect women regardless of age; body mass index; weight gain during pregnancy; baby's weight at birth; mode of delivery; and exercise training level before, during, and after pregnancy. The Marine Corps currently gives Marines six months following their 42-day postpartum convalescent leave, or approximately seven and a half months, to rehabilitate before it requires them to resume fitness testing. However, seven and a half months is not enough time to regain sufficient muscular strength and endurance in the transversus abdominis and pelvic floor muscles to enable safe fitness testing due to the high-impact and/or high-intensity of the constituent test events and the sustained repetitive nature of the trunk flexion event (i.e., abdominal crunch). If postpartum women do not return in a graduated and progressive manner to high-impact activities and activities that increase intra-abdominal pressure, such as trunk flexion and heavy lifting, they are more prone to incidence or recurrence of diastasis recti, abdominal fascia herniation, urinary and fecal incontinence, and/or pelvic organ prolapse. These substantial injuries affect long-term health and readiness of postpartum women. Additionally, the resource best suited to postpartum rehabilitation is physical therapy. Specifically, physical therapists certified in women's health, and to a lesser degree in sports, are qualified to develop an individualized rehabilitation program that addresses core musculature deficits.

Conclusion: The current timeline for resumption of fitness testing should be extended to no earlier than 9 months postpartum. Additionally, postpartum Marines should receive a referral for physical therapy either prior to childbirth or upon discharge from their birthing facility following delivery so that they can undergo rehabilitation with a physical therapist who has women's health training and experience.

DISCLAIMER

THE OPINIONS AND CONCLUSIONS EXPRESSED HEREIN ARE THOSE OF THE INDIVIDUAL STUDENT AUTHOR AND DO NOT NECESSARILY REPRESENT THE VIEWS OF EITHER THE MARINE CORPS COMMAND AND STAFF COLLEGE OR ANY OTHER GOVERNMENTAL AGENCY. REFERENCES TO THIS STUDY SHOULD INCLUDE THE FOREGOING STATEMENT.

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Preface

Do you ever wonder why we do what we do as Marines, particularly regarding policy and standing operating procedures? Sometimes the answer is, “because we have always done it that way,” which I would argue is not really an answer. Sometimes there is an answer, but it makes no sense at all. And sometimes the answer becomes logical once you understand the whole picture or how decision-makers are weighing the complex variables involved. But what would the answer be if you started from scratch—if you examined the problem afresh? I aim to do just that for the question, “how long after childbirth does it take for a postpartum Marine to recover and rehabilitate sufficiently to be able safely to resume fitness testing?” While I apply this question to Marines, my findings can be applied across the services and could serve to inform policy across the Department of Defense. If the military services genuinely want to manage their talent and optimize readiness, they need to invest in their members. While what biology says about the recovery and rehabilitation process may not be convenient in the short-term, aligning policy with biology serves long-term service objectives.

In terms of acknowledgements, I thank, first and foremost, my husband, Kent, and my daughter, Finley, for their patience and understanding. They gave me the time that I needed to examine my research question comprehensively and to compose this paper. I thank Angelique Ruiz, Physical Therapy Department Head at the John H. Bradley Branch Health Clinic, Quantico, Virginia, for motivating me to pursue this research topic and for confirming the viability of my concern regarding proper postpartum rehabilitation. I thank Dr. C. Doug McKenna, Dean of Academics, Command and Staff College, Marine Corps University, for embracing my research proposal and offering to serve as my mentor. He also helped me develop and refine my research question, which shaped my approach to this paper, and he provided

thoughtful critique throughout my research and writing process. I thank Major Misty Posey, USMC, in the Marine Corps Force Integration Office for encouraging me and championing my research. She provided venues and contacts that enabled me to socialize what I have learned and my associated recommendations. Brian McGuire, Physical Readiness Programs Officer, Training and Education Command, served as a sounding board and identified potential gaps in my research. He also provided information regarding the Marine Corps orders review and modification process and regarding the Marine Corps Physical Fitness Program. When I was trying to answer the question of what, if any, medical information informed the Marine Corps' current policy, Brian McGuire directed me to Captain Vincent L. DeCicco, USN, Director of Clinical Programs, Health Services, Headquarters Marine Corps. Captain DeCicco discussed the rationale and justification for the current policy with me. Captain Michele Weinstein, USN, Physical Therapy Department Head at the David R. Ray Branch Health Clinic, Quantico, Virginia, provided me valuable information regarding the physical therapy field within the Navy and across the military. She also discussed the different physical therapy specialties and their prevalence within the military. Additionally, I thank Cindy Evans, Interlibrary Loan Technician at the Library of the Marine Corps, Quantico, Virginia, for responding to my numerous interlibrary loan requests. She was consistently responsive and obtained the requested material quickly. Her role was particularly important, because without her help I would have needed to commute to the National Library of Medicine in Bethesda, Maryland more frequently to access relevant journal articles. I also thank the Leadership Communication Skills Center staff for their instruction and guidance and their constant willingness to answer questions.

Because most of the relevant medical or physical therapy studies did not extend longitudinally beyond 6 months postpartum, I sought out women's health physical therapists

who have significant postpartum rehabilitation experience to inform my paper with their clinical observations. Dianne Edmonds, Director and Founder of The Pregnancy Centre in Australia, provided extensive documentation and personally invested herself in my project. I thank her for all the time and energy she dedicated to sending me information and answering my questions. She also raised my awareness regarding the role of the pelvic floor and the importance of pelvic floor rehabilitation. Additionally, Dianne reached out to Judith Thompson, a continence and women's health physical therapist who has published extensively on pelvic floor dysfunction, and Marianne Ryan, a prominent prenatal and postpartum physical therapist and clinical director in New York City, who both provided additional input and feedback. I thank Marianne Ryan for discussing the role of hormones in postpartum rehabilitation and for giving me an advance copy of her book, *Baby Bod*®, which puts much of the current body of knowledge into layman's terms.

This paper represents the product of the collective effort of those acknowledged above, as well as others who are not listed by name. Thank you for supporting my work.

Introduction

Prior to January 6, 2015, US Marine Corps* policy required postpartum women to resume fitness testing no *later* than six months after return to full duty following the 42-day postpartum convalescent leave period. While the modified policy now states that women will resume fitness testing no *earlier* than six months after returning to full duty, it still assumes that approximately seven and a half months is long enough to undergo postpartum rehabilitation and resume fitness testing safely. Although seven and a half months may seem like a sufficient period to recover, the physiological and morphological changes that a woman undergoes during the antenatal and postpartum periods are extensive, regardless of the woman's fitness level before pregnancy or the activity level she is able to maintain through the antenatal period. Even with the recent modification, current Marine Corps policy regarding postpartum fitness testing does not afford Marines sufficient time to recover properly or provide appropriate recovery resources to facilitate a return to full duty activities prior to resuming fitness testing.

To make this assertion, one must first review any current Marine Corps policy documents regarding postpartum Marines and fitness testing requirements. Then one must consider the comprehensive physiological and morphological changes the human body undergoes during pregnancy and the postpartum process through which the body returns to prepregnancy function and form. One then can discern the requisite rehabilitation steps to address the associated changes and to resume fitness activities safely and progressively. Only after analyzing this data collectively can one reconcile Marine Corps policy with the informed rehabilitation process and recommend policy modifications.

* All further uses of "Marine Corps" will refer to the US Marine Corps unless otherwise indicated.

Current Marine Corps Policies

The Marine Corps has two policy documents that codify service-level postpartum physical fitness guidance and requirements: Marine Corps Order (MCO) 5000.12E with change 1-2, *Marine Corps Policy Concerning Pregnancy and Parenthood*, dated December 8, 2004, and MCO 6100.13 with change 1, *Marine Corps Physical Fitness Program (MCPFP)*, dated August 1, 2008. These orders are managed by Administration and Resource Management, Headquarters Marine Corps (HQMC). Marine administrative message (MARADMIN) 005/15, recently published on January 6, 2015, promulgates a second change to MCO 6100.13, which alters the time period during which a postpartum Marine is required to resume fitness testing.

The Manpower Plans and Policy Division at Manpower & Reserve Affairs has proponency for MCO 5000.12E with change 1-2, hereafter referred to as the pregnancy and parenthood order. Training and Education Command under Marine Corps Combat Development Center has proponency for MCO 6100.13 with change 1, hereafter called the MCPFP. A given proponent is responsible for reviewing the orders for which it has proponency at least every two years. Upon review, the proponent may determine whether the order requires revision, change, or no change. In addition to regular programmatic review, a proponent may be tasked to review an order outside the normal review schedule should the need arise. The proponent typically announces changes to orders via MARADMIN or all Marine Corps activities message (ALMAR).¹

The parenthood and pregnancy order is the Marine Corps' primary policy document regarding pregnant and postpartum service members.* While the majority of the order provides

* MCO 5000.12E W/CH 1-2 also pertains to Marines considering adoption of an infant or child and to male single parent Marines; however, these aspects of the policy are not relevant to the subject under consideration.

administrative guidance regarding limitations and responsibilities for relevant parties such as health care providers, commanding officers, and the pregnant service member, it only provides limited policy information applicable to postpartum women. In listing responsibilities of the pregnant Marine, the order states that, following delivery, service members will participate in an exercise program to prepare for the physical fitness test (PFT) as soon as is medically authorized. Postpartum Marines are also required to take the PFT and conform to service body composition standards no later than six months after being returned to full duty by a health care provider, which is normally immediately upon completion of the 42-day postpartum convalescent leave period.^{*,2} The policy also states that a health care provider may grant a postpartum Marine additional time to prepare for fitness testing and conform to body composition standards in the case of “unique medical circumstances.”^{†,3}

Although the order provides the timeline of no later than six months after return to full duty in paragraph 4.a.(6) regarding individual responsibilities and reiterates this timeline in paragraph 5.b.(7) on notification procedures, paragraph 9.a.(1) concerning general limitations exempts the postpartum Marine from routine physical training and the PFT for six months following return to full duty.⁴ This incongruity was addressed indirectly by the second change to the MCPFP promulgated in MARADMIN 005/15, but it has not been resolved explicitly in the pregnancy and parenthood order itself.

In terms of educational resources, the pregnancy and parenthood order states that commanding officers will provide appropriate training to all Marines regarding the contents of the order and on various services available to support Marines in making family life decisions.

* In providing this direction, pregnancy and parenthood order refers the reader to the MCPFP order, which was MCO P6100.12 at the time.

† No examples of “unique medical circumstances” are provided in the order.

The order also encourages Marines to seek counseling and support regarding pregnancy and parenthood from Marine Corps Community Services (MCCS) and medical treatment facilities staffs as well as chaplains.⁵

The MCPFP establishes procedures for program management and details requirements regarding combat conditioning, remedial conditioning, the PFT, and the combat fitness test (CFT). Although the order waives Marines from completing the PFT and CFT upon confirmation of pregnancy, the MCPFP dictates that Marines will participate in a medically approved exercise program throughout pregnancy and the postpartum period. The order then states that as soon as possible following delivery, postpartum Marines should resume physical conditioning.⁶

In Chapter 1, paragraph 6.f. regarding medical considerations specific to pregnancy/postpartum, the MCPFP order requires Marines to complete the PFT or CFT, depending on the semi-annual period during which the test is administered, no later than six months after return to full duty. The return to full duty normally coincides with completion of a 42-day postpartum convalescent leave period.* In the case of complicated pregnancies or deliveries, a health care provider may afford the Marine additional recovery time to return to full duty and complete the requisite semi-annual fitness test.⁷ In Chapter 1, after paragraph 6.f.(2) states that postpartum Marines will fulfill the PFT or CFT requirement no later than six months after return to full duty, paragraph 7.a.(4) grants fitness testing exemption to postpartum Marines for six months following return to full duty.⁸ This incongruity parallels the inconsistency presented in the pregnancy and parenthood order.

* The Marine Corps currently does not have a reliable means to determine the percentage of postpartum Marines who are granted convalescent leave that exceeds 42 days. Starting upon discharge from the birthing facility, 42 days is the standard length of postpartum leave regardless of delivery method (i.e., vaginal or caesarian section).

While these two paragraphs seem contradictory to some degree, the aforementioned MARADMIN 005/15, *Change 2 to the MCPFP*, clarifies the policy through its modification of Chapter 1, paragraph 6.f.(2). This change replaces “no later than” with “no earlier than” six months after returning to full duty.⁹ The Marine then has the remainder of the semi-annual period during which the six-month period expires to fulfill the fitness testing requirement per the MCPFP. The rationale for the change, as stated in the MARADMIN, is that current policy at the time of issuance related to postpartum PFT/CFT requirements was inconsistent with the period afforded female Marines to meet other standards, specifically body composition,^{*} and with the pregnancy and parenthood order. While the Marine Corps’ Training and Education Command presents this change as an extension of the time period provided to postpartum Marines, in actuality it only serves to clarify the inconsistency inherent in the previous iteration of the order by confirming that the fitness testing exemption granted in Chapter 1, paragraph 7.a.(4) was indeed the intended policy. Also, while the presented rationale indicates that the change creates parity between the MCPFP and the pregnancy and parenthood order, the change does no such thing, because the incongruity is also inclusive in the pregnancy and parenthood order and has not been concurrently clarified or updated. Regardless, the MARADMIN does clarify the exemption timeline in the MCPFP and presumes agreement across other policy documents.

The current Marine Corps policy regarding postpartum resumption of fitness testing is based on input from Health Services, Headquarters Marine Corps. This office, and specifically the Medical Officer to the Marine Corps, is responsible for advising the Commandant of the Marine Corps (CMC) and the headquarters staff on all matters regarding healthcare.¹⁰ In

^{*} Female Marines are not eligible for assignment to the body composition program (BCP) or the military appearance program (MAP) during pregnancy, during the 42-day postpartum convalescent leave period, and for six months following return to full duty per MCO 6110.3 with change 1, *Marine Corps Body Composition and Military Appearance Program*.

providing input regarding postpartum fitness testing, the Health Services staff consulted current American College of Obstetricians and Gynecologists (ACOG) guidelines.¹¹ Informed by the ACOG Committee Opinion entitled “Exercise during Pregnancy and the Postpartum Period,” Health Services staff indicated that “by the [sixth] week postpartum the physiological effects of pregnancy have resolved.” As such, Health Services staff assessed that having six months following return to full duty to “achieve sufficient physical fitness to successfully complete a [physical fitness assessment] is physiologically feasible.”¹² That is to say, because the effects of pregnancy are resolved within six weeks following childbirth, six months is enough time to regain sufficient fitness to pass a PFT or CFT.

The MCPFP also provides guidance regarding postpartum physical training. Specifically, the order informs commanders and officers-in-charge (OIC) that postpartum Marines require a progressive training routine to return to prepregnancy fitness levels.¹³ The order also indicates remedial conditioning program (RCP) assignment as one tool available to commanders to assist postpartum Marines. RCP is designed to provide tailored, supervised fitness training to improve Marine fitness and appearance levels that have been degraded for any reason, an example of which is pregnancy.¹⁴ RCP will be discussed further in the “Recovery Resources” section of this paper.

Understanding the requisite test events described in the MCPFP is equally important to knowing the timeline requirements for postpartum exercise and fitness testing resumption. Chapter 2 describes the PFT, and Chapter 3 describes the CFT. The PFT consists of a pull-up or flexed-arm hang event, an abdominal crunch event, and a 3.0-mile run. While no sequence is prescribed by the MCPFP, the events are typically conducted in the order listed above. For the pull-up/flexed-arm hang event, female Marines have the option to perform a maximum set of

complete “dead hang”^{*} pull-ups or to execute a flexed-arm hang for as long as possible but for up to 70 seconds. The flexed-arm hang requires the Marine to hang from the pull-up bar starting with her chin above the bar. Hang time continues to accrue as long as the Marine maintains some degree of arm flexion. In order to pass the PFT, the Marine must perform at least three pull-ups or hang for at least 15 seconds. The abdominal crunch event requires the Marine to execute as many abdominal crunches as possible within a 2-minute time limit. Maximum points are awarded if the Marine completes 100 abdominal crunches, but the Marine must perform at least 40 crunches to pass the PFT. For the 3.0-mile run, the Marine must run the prescribed distance on a measured course over reasonably level ground as quickly as possible. Women achieve maximum points for the event if they run the course in 21:00 minutes or less and pass if they run the course in 36:00 minutes or less. Achieving the minimum passing score in each event is not sufficient to receive an overall passing score unless the Marine is at least 46 years old. Although individual events scores are performance-based irrespective of age, the minimum passing score is lower for older age groups.¹⁵

The CFT consists of a movement to contact event, an ammunition lift event, and a maneuver under fire event. The Marine wears camouflage utilities and boots for the test.[†] The movement to contact event requires a Marine to run 880 yards (805 meters) over reasonably level ground in as little time as possible. The ammunition lift requires a Marine to lift a 30-pound ammunition can from shoulder height to overhead as many times as possible within a 2-minute time limit. The maneuver under fire event is a 300-yard (274-meter) shuttle run that

^{*} “Dead hang” refers to the fact that the Marine’s arms must be fully extended in the starting position and at the end of each repetition and that the Marine must avoid using a pendulum-like motion to enhance the ability to perform the pull-up.

[†] The utility blouse is optional for the movement to contact, mandatory for the maneuver under fire, and not permitted for the ammunition lift.

includes a variety of combat-related tasks: high crawls, a buddy drag, a buddy carry, ammunition resupply, a grenade throw, and agility running. For the buddy drag and carry, a Marine's buddy must be within 10 pounds of the Marine's weight and within 6 inches of the Marine's height. The ammunition resupply requires a Marine to carry two 30-pound ammunition cans for two legs of the shuttle run. Maximum and minimum event performance criteria depend on the age group and sex of the Marine executing the test.¹⁶ As apparent from the descriptions of the requisite PFT and CFT events, both tests require high levels of cardiovascular fitness and total-body muscular strength and endurance.

Antenatal Physiology and Morphology

The antenatal, or prenatal, period extends from fertilization through birth, or parturition, and thus includes labor and delivery. During the antenatal period, which typically lasts 40 weeks, the human body undergoes profound physiological, or functional, and morphological, or structural, changes in order to accommodate the needs of the developing fetus. The changes that are most relevant to physical fitness considerations are hematological, cardiovascular, respiratory, and musculoskeletal. Although these types of changes are facilitated by hormonal changes, endocrine changes will not be discussed as they are outside the scope of this thesis.

Hematological and cardiovascular changes are closely related, as hematological changes affect the blood and cardiovascular changes relate to the heart and circulatory system. In terms of hematological changes, maternal blood volume begins to increase during the first trimester, plasma volume expanding by approximately 15 percent from prepregnancy levels during the 12-week period. Overall, blood volume expansion during pregnancy averages 40 to 45 percent above prepregnancy levels but can as much as double. Because plasma volume changes exceed that of blood cell volume increases, whole blood viscosity decreases.¹⁷ Cardiac functional

changes become apparent during the first eight weeks of pregnancy. Cardiac output increases as early as the fifth week due to reduced systemic vascular resistance and increased heart rate. These changes enable maternal cardiovascular integrity to be maintained while meeting the demands of the fetus.¹⁸

The respiratory system undergoes substantial antenatal adaptations that largely improve lung function.¹⁹ Over the course of pregnancy, the diaphragm rises approximately 4 centimeters (1.6 inches) as the uterus expands. Although the thoracic circumference also increases by approximately 6 centimeters (2.4 inches), this increase is not enough to prevent a reduction of residual lung volumes. Despite the reduced lung volumes, the total lung capacity remains unchanged, or if it changes, it decreases less than 5 percent at full term. As pregnancy advances, the respiratory rate remains unchanged, but tidal volume and resting minute ventilation significantly* increase. Tidal volume is the amount of air displaced between normal inhalation and exhalation. Resting minute ventilation is the amount of air inhaled or exhaled per minute.²⁰ The increase in tidal volume delivers more oxygen into the lungs, and because of hematological changes, it facilitates an increase in total oxygen-carrying capacity. Oxygen consumption increases approximately 20 percent during pregnancy and 40 to 60 percent during labor. Regardless, oxygen delivery clearly exceeds the oxygen requirements of pregnancy.²¹

Cardiovascular fitness refers to the ability of the heart and lungs to supply oxygen-rich blood to muscle tissue and the muscles' ability to use oxygen to release energy for movement. As such, cardiovascular fitness encompasses hematological, cardiovascular, and respiratory considerations. The cardiovascular status of a normal pregnant woman is similar in many ways to that of a trained non-pregnant woman during exercise: expanded blood volume and increased

* Within this paper, any form of the word “significant” denotes statistical significance. Similarly, “insignificant” denotes statistical insignificance.

flow rates. When physically fit women maintain their exercise program during pregnancy, the pregnancy-induced cardiovascular adaptations overlay the preexisting training adaptations with at least an additive effect.²² This effect means that women can maintain high cardiovascular fitness levels during the antenatal period by maintaining an appropriately strenuous exercise program including aerobic and strength training.²³ Additionally, in the case of sedentary women, initiating a regular exercise regimen during pregnancy improves maternal cardiovascular fitness without identifiable risk to mother or fetus.²⁴ Beyond maintaining or improving cardiovascular fitness, exercising through pregnancy reduces fat deposition and physical discomfort during pregnancy. It also shortens active labor; decreases the need for medical intervention during labor and delivery; and increases incidence of uncomplicated, spontaneous delivery.²⁵

Perhaps the most drastic musculoskeletal adaptation involves increased peripheral joint laxity, which generally increases over the course of pregnancy. Although such increased joint mobility is commonly considered to be associated with the protein hormone relaxin, researchers have not yet attributed ligament relaxation to a specific pregnancy hormone or a combination thereof.* Regardless of the cause, peripheral joint laxity during the antenatal period is a reality.²⁶ Effects of ligament relaxation extend to the viscera, or internal organs, because they are supported by ligaments and fascial connections. In particular, the uterine ligaments are distended up to four times their normal length during pregnancy.²⁷ The connective tissue softening that leads to the increased laxity also has ramifications for muscle function, specifically that of abdominal and pelvic floor muscles.

* A study published by Marnach, et al., in 2003 found that increased joint laxity does not correlate with maternal serum levels of estradiol, progesterone, or relaxin. Along with their findings, Marnach, et al., describe the controversy that exists in the literature regarding the four primary serum hormones (cortisol, estradiol, progesterone, and relaxin) and the development of joint laxity or ligament relaxation.

During the antenatal period, the abdominal muscles undergo structural changes that persist into the postpartum period. Four muscle pairs comprise the anterior abdominal wall: the rectus abdominis, internal oblique, external oblique, and transversus abdominis (depicted below in Figure 1). The rectus abdominis serves to flex the trunk by approximating the pelvis and ribcage.²⁸ The connective tissue, or fascia, that connects the left and right rectus muscles and runs from the xyphoid to the pubic symphysis is the linea alba, the width of which is referred to as the inter-recti distance.²⁹ The oblique abdominals are particularly active during twisting motions. The external oblique functions in rotating the trunk to its opposing side, while the internal oblique rotates the trunk to its same side.³⁰ The transversus abdominis is the primary spine stabilizer in the abdominal muscle group.³¹

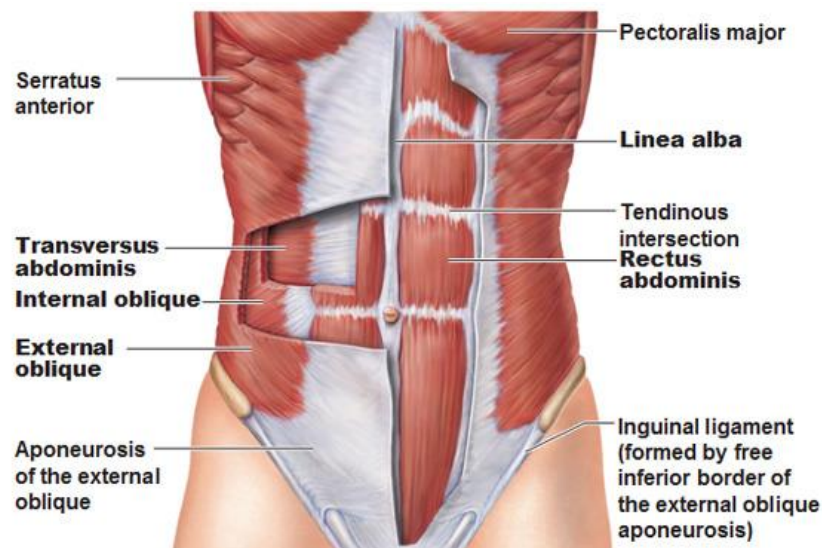


Figure 1. Abdominal muscle diagram. The anterior abdominal wall is comprised of the rectus abdominis, external oblique, internal oblique, and transversus abdominis muscle pairs. The linea alba is the connective tissue, or fascia, that connects the two bellies of the rectus abdominis.

At about 12 weeks of gestation, the growing uterus rises out of the pelvis and comes in direct contact with the abdominal wall. Then at approximately 20 weeks, the top of the uterus reaches the height of the umbilicus, or navel, and continues to grow as pregnancy progresses.³²

The maternal inferior thoracic diameter increase alters the spatial relationship of the abdominal

muscle attachments and increases the distance between muscle attachments, resulting in muscle lengthening. To be more specific, in the case of the rectus abdominis, absolute and normalized muscle lengths increase from 18 to 38 weeks of gestation.³³ This increase likely reflects muscle fiber length increase;³⁴ however, the rectus abdominis does exhibit thinning during pregnancy.³⁵ The muscle also widens. With an increase in length and width, the cross-sectional area increases.³⁶ In addition to dimensional changes specific to the individual muscles, the rectus abdominis muscle-pair separation increases above, at, and below the umbilicus. The abdominal separation 4.5 centimeters (1.8 inches) below the umbilicus increases between gestational weeks 18 and 30, while the separation at and above the umbilicus continues to increase from 18 to 38 weeks.³⁷ In conjunction with this muscle separation, the linea alba, which is the connective tissue between the rectus muscles, widens.³⁸ The rectus abdominis muscle curves around the abdominal protuberance as pregnancy progresses instead of maintaining the normal vertical orientation. The resulting altered line of action likely contributes to antenatal abdominal muscle functional deficits.³⁹ Specifically, women demonstrate a diminished ability to stabilize the pelvis against resistance between 30 and 38 weeks of gestation.⁴⁰ Such structural changes and decreased functional abilities occur irrespective of maintaining an antenatal aerobic exercise regimen.⁴¹

An inter-recti distance of greater than 2 centimeters at a given assessment point with respect to the umbilicus is generally considered diastasis recti.⁴² In a study of six primigravid* subjects with a single fetus who regularly conducted aerobic exercise throughout their pregnancies, Gilleard and Brown observed abdominis muscle separation widths at, above, and below the umbilicus that exceeded 2 centimeters at 38 weeks gestation in all subjects.⁴³

* “Primigravid” means pregnant for the first time.

Although the small sample size may preclude this rate of diastasis recti from adequately representing the broader maternal population, a more recent study published in February 2015 by Mota, et al., found diastasis recti at 2 centimeters (0.8 inches) below the center of the umbilicus in 100 percent of the subject population of 84 primigravid women at 35 weeks gestation.⁴⁴ Although Mota, et al., only measured at one location along the linea alba, their sample size and the reliability of their measuring techniques make the findings applicable to the broader maternal population.

The pelvic floor includes the structures that comprise the bottom of the abdominal canister. It is a three-dimensional structure made up of several muscles and an extensive, complex fascial support system.⁴⁵ The primary functions of the pelvic floor are to support the weight of the abdominal and pelvic organs, maintain intra-abdominal pressure, allow voluntary control of urination and defecation, and enable sacrum and coccyx flexion. In women, the pelvic floor also facilitates fetal movement through the birth canal. The pelvic floor's ability to perform these functions effectively depends on constituent muscle fiber integrity and muscle tone maintenance.⁴⁶ From 20 weeks gestation, pelvic floor muscle strength exhibits a decline that may interfere with muscle function.⁴⁷ Additionally, fascial tissue stretches and may tear slowly over time as the weight of the fetus increases.⁴⁸

Pelvic floor muscles are placed under substantial stress during delivery. Ultrasound and magnetic resonance imaging show major pelvic floor muscle injuries in 20 to 26 percent of women following vaginal delivery.⁴⁹ One specific pelvic floor muscle that is part of the levator ani muscle group is known to stretch over three times its resting length during the second stage of labor. More than one third of women who deliver vaginally also experience levator avulsion, which means that the muscle is separated from its insertion. Increased maternal age increases the

risk of avulsion. Avulsion is associated with highly significant reduction in muscle strength. This deficit can also lead to bladder prolapse, a condition where the bladder descends from its normal position.⁵⁰ Vaginal delivery also results in partial denervation of pelvic floor muscles in 80 percent of women. Women who experienced long, active second stage labor showed greater evidence of denervation. Damage to the nerve to the levator ani may result in atrophy of the denervated muscle, thereby placing more stress on the pelvic fascia. Such increased fascial stress may result in organ prolapse or separation of the fascia over time.⁵¹ The majority of direct pelvic floor fascia injuries are thought to occur during vaginal delivery. Pelvic floor fascia may detach or tear during deliver, thereby destabilizing the pelvic floor.⁵²

Pelvic floor muscle and fascia integrity and function are also essential to the preservation of continence, particularly during tasks that increase intra-abdominal pressure. If pelvic floor muscles are weak, if they do not contract at the right time, or if the pelvic floor fascia is lax or torn, the pelvic floor will be unable to control urine loss.⁵³

Collectively, the hematological, cardiovascular, respiratory, and musculoskeletal changes a woman undergoes during the antenatal period are considerable. Discussion of these changes clearly shows the extent to which pregnancy changes physiology and morphology across the body's systems. Such structural and functional changes accumulate over the gestational period to accommodate the developing fetus and its needs. Naturally, this 40-week process is not reversed or resolved immediately upon childbirth.

Postpartum Physiology and Morphology

The puerperium is the period following delivery during which most pregnancy-induced maternal anatomical and physiological changes return to the nonpregnant state. While puerperium duration varies, it generally is considered to last until 6 weeks postpartum.⁵⁴

Although most physiological adaptations return to a nonpregnant state during puerperium, many cardiovascular changes persist for months following delivery, and some changes, such as those to pelvic musculature and cardiac remodeling, persist for years.⁵⁵ Additionally, a return to nonpregnant physiology does not necessarily equate to a return to nulliparous* morphology; a number of maternal characteristics, beyond those discussed in this paper, do not return to nulliparous form.

Uterine involution, or shrinkage, begins immediately after delivery. The uterus and its inner membrane, the endometrium, return roughly to pregravid size by eight weeks following delivery; however, after each successive delivery, the uterus remains slightly larger following involution than it was before that pregnancy.⁵⁶ In conjunction with involution, postpartum uterine discharge, called lochia, begins as a flow of blood that diminishes in volume. It has a reduced blood component within 3 to 4 days postpartum but continues as a brownish or pink discharge with a median duration of 22 to 27 days.⁵⁷

Between natural blood loss during delivery and through lochia and increased postpartum urine production, blood volume typically returns to nonpregnant levels by one week after delivery. After the first 2 days postpartum, systemic vascular resistance and blood pressure begin to rise steadily to normal values.⁵⁸ Deep vein vessel size significantly reduces and venous flow velocity concomitantly increases during the puerperium. Cardiac output peaks at 24 weeks' gestation and after delivery slowly returns to nonpregnant values. However, even after 1 year postpartum, cardiac output remains significantly higher than prepregnant values in both primiparous and multiparous† women.⁵⁹

* The term “nulliparous” refers to a woman who has not borne a child.

† “Primiparous” refers to a woman who has borne one child, and “multiparous” means having given birth to more than one child.

Regarding cardiovascular fitness, women who are sedentary during the antenatal period consistently have lower maximal oxygen uptake (VO_{2max}) postpartum than they did pre-pregnancy.⁶⁰ However, through moderate exercise, a woman can maintain peak ventilation and absolute maximal aerobic capacity. In fact, the combination of pregnancy and physical training can even improve maximal aerobic capacity.⁶¹ Well-conditioned women who maintain at least a moderate exercise regimen, comprised of three or more 30-minute aerobic sessions weekly, during pregnancy and postpartum have a small but statistically significant increase in postpartum VO_{2max} .⁶² The enhanced training effect of pregnancy becomes most apparent six months to one year after delivery.⁶³

The increased joint laxity that peaks in the third trimester persists into the postpartum period and remains at near third trimester level even at 6 weeks postpartum.⁶⁴ While joint laxity does not resolve immediately, joint strengthening usually completes within three to five months of childbirth.⁶⁵ The exception to this joint strengthening timeline is lactating women, who remain under the influence of pregnancy hormones for as long as they are breastfeeding. In the case of nursing women, they may see persistent joint laxity for up to three months following lactation termination.⁶⁶ Although the body of research regarding postpartum connective tissue compromise is extremely limited, numerous physical therapists both within the United States and abroad have observed persistent ligament relaxation in their patients that follows the timeline described above.⁶⁷

The abdominal muscles experience immediate change following delivery. Upon childbirth, the effective total rectus abdominis muscle length increases suddenly when the stretch from the uterus is removed. The sudden increase in effective length affects the rectus abdominis' ability to produce tension, and thus contributes to functional deficits.⁶⁸ The cross-sectional area

of the rectus abdominis returns to values similar to nulliparous values after approximately 8 weeks postpartum. Although muscle width remains significantly different from nulliparous values at 12 months postpartum, width steadily declines by 8 weeks and plateaus at some point between 6 and 12 months postpartum. Because cross-sectional area is a function of length and width, a combined consideration of cross-sectional area and width resolution timelines implies that muscle length returns to prepregnancy values between 8 weeks and 6 months postpartum. While the rectus abdominis steadily thickens over the course of the 12-month postpartum period, the muscle remains significantly thinner than it was prepregnancy.⁶⁹ The reduction in muscle thickness manifests itself as a decrease in concentric and eccentric trunk flexion strength that is observed at least through 6 months postpartum.⁷⁰

The rectus abdominis muscle separation widths at, above, and below the umbilicus narrow between 38 weeks of gestation and 4 weeks postpartum to widths observed between 22 and 26 weeks of gestation.⁷¹ The ability of the abdominal muscles to generate torque remains reduced at 8 weeks postpartum; therefore, exercises that require significant torque production are unsuitable. This means that trunk flexion activities such as sit-ups are contraindicated. Additionally, the ability to stabilize the pelvis against resistance remains reduced postpartum. This reduced capacity is problematic because correct performance of most abdominal exercises requires stabilization of the pelvis.⁷²

Even by 6 months postpartum, the inter-recti distance does not return to prepregnancy values. When Liaw, et al., compared inter-recti distance measurements of postpartum women to nulliparous age-matched counterparts in a control group, they found that inter-recti distances, both above and below the umbilicus, in women at 6 months postpartum exceed that of their age-matched counterparts, who are without previous pregnancy. Postpartum women exhibit

significant reduction in inter-recti distance at the upper margin of the umbilical ring and 2.5 centimeters above the umbilicus between 7 weeks postpartum and 6 months postpartum; however, the change below the umbilicus over the same period is insignificant.⁷³ In addition to the study by Liaw, et al., a study by Coldron, et al., shows that inter-recti distance does not return to control values at 12 months postpartum but the value plateaus by 6 months.⁷⁴

In terms of abdominal muscle function, muscle strength and static endurance improves between 7 weeks postpartum and 6 months postpartum; however, after 6 months, postpartum women still exhibit less strength and endurance than their nulliparous counterparts. Additionally, the increased postpartum inter-recti distance measurements correlate negatively with strength and endurance of trunk flexors and rotators. In particular, the reduction in the inter-recti distance between 7 weeks and 6 months postpartum was associated with an improvement in trunk flexor strength.

Collectively, these findings suggest that the incomplete recovery of the linea alba may create a functional deficit that reduces the ability of the abdominal musculature to generate force.⁷⁵ In other words, the inter-recti distance in postpartum women does not recover to nulliparous values even at 6 months postpartum, and that increased linea alba width correlates with abdominal functional deficit. Both structural and functional deficits persist to at least six months after childbirth. The findings of Liaw, et al., coupled with the findings of Coldron, et al., that indicate persistent decreased muscle thickness, increased muscle width, and increased inter-recti distance at 12 months postpartum imply that the postpartum mechanical disadvantage induced by pregnancy may not resolve.⁷⁶ The results of Liaw, et al., are more appropriate to consider than many other studies that examine inter-recti distance because Liaw, et al., followed participants for 6 months postpartum, considered a larger sample size, and used ultrasound

imaging to measure inter-recti distance at several locations to more objectively quantify diastasis.

In the Liaw, et al., study, the postpartum and nulliparous women had not received any abdominal muscle training or engaged in any other regular exercise within the previous six months. Additionally, the postpartum women did not engage in abdominal muscle training or regular exercise during the length of the study; they merely performed activities consistent with daily living.⁷⁷ One might argue that such study participant conditions negates the applicability of the findings to a postpartum Marine population, whose members would be engaged in some degree of regular exercise assuming their medical condition allows it; however, this is not the case. In fact, because the Liaw, et al., study investigates the natural recovery of inter-recti distance and abdominal muscle function, it can actually be applied more broadly. Since the study is unencumbered by variables specific to a given exercise regimen, studies regarding the effects of exercise on inter-recti distance can be overlaid on the Liaw, et al., findings. A systematic review published in March 2014, which comprehensively reviewed studies that examined the effects of exercise on diastasis recti and were published no later than July 31, 2012, indicated that the degree to which abdominal exercise reduces postpartum diastasis recti is unclear. The review, however, does state that transversus abdominis muscle activation could potentially protect the linea alba and help prevent or reduce diastasis recti, because activation and exercise of the transversus abdominis draws the bellies of the rectus abdominis together and increases fascial tension.⁷⁸ Regardless of whether abdominal exercise can reduce the inter-recti distance, multimodal* physical therapy treatment has enabled postpartum women to restore

* Multimodal treatment is treatment that involves a combination of approaches and may include general education; strengthening, kinesthetic, and functional exercises; muscle reeducation; and posture correction.

optimal strategies for transferring loads through the abdominal canister irrespective of diastasis recti closure.⁷⁹

As discussed in the preceding antenatal section, the vast majority, if not all, pregnant women have diastasis recti by 35 weeks gestation. At 6 to 8 weeks postpartum and also at 12 to 14 weeks postpartum, the percentage of women exhibiting diastasis recti declines to around 50 percent. After six months, 39 percent of the postpartum population has diastasis recti.⁸⁰ One may hypothesize that certain factors predispose a woman to experiencing diastasis recti; however, Mota, et al., did not identify any significant risk factors associated with the presence of diastasis recti at 6 months postpartum. Specifically, the following variables showed no significant correlation with the presence of diastasis recti: age; body mass index (BMI) before pregnancy or at 6 months postpartum; weight gain during pregnancy; joint hypermobility; baby's weight at birth, abdominal circumference at 35 weeks gestation; or exercise training level (defined as at least three times weekly) before, during, and after pregnancy.⁸¹ These findings were comparable to the one other study that examined similar variables.⁸² Such studies illustrate that diastasis recti, as well as less significant persistent rectus abdominis separation, occurs irrespective of the woman's fitness level before pregnancy or the activity level she is able to maintain through the antenatal period. Abdominal separation also occurs irrespective of BMI or weight gain. Whether a woman is physically active and able to remain so and regardless of the extent of her weight gain, she will experience this pregnancy-induced change and the corresponding functional deficit. Increased parity, however, does seem to increase the risk of diastasis recti.⁸³ This means that women are more likely to have diastasis recti upon each subsequent pregnancy.

Postpartum pelvic floor damage can result from the trauma of second stage labor and vaginal delivery or from microtrauma over prolonged periods of time. Microtrauma can occur during pregnancy from the increased weight of the fetus and/or following childbirth due to non-optimal strategies for transferring loads through the pelvis.⁸⁴ Although women who give birth via caesarean section do not experience trauma resulting from vaginal delivery and experience reduced, if any, second stage labor trauma, they can still be afflicted by microtrauma.

Pelvic floor dysfunction includes urinary incontinence, anal incontinence, and pelvic organ prolapse.⁸⁵ In the case of urinary incontinence, on average 30 percent of women with vaginal deliveries experience the dysfunction compared to 15 percent of women who delivered by caesarian section. At 1 year postpartum, 23 percent of women who deliver vaginally and 10 percent of those delivering via caesarian section experience stress urinary incontinence. Six years following delivery, the prevalence of urinary leakage was comparable or slightly higher than at 1 year postpartum.⁸⁶ Incidence of anal or fecal incontinence is much lower and generally is limited to women with anal sphincter rupture; incidence of rupture is of primary significance rather than mode of delivery.⁸⁷ Pelvic organ prolapse is associated significantly with vaginal delivery, age over 30 years at delivery, and increased parity.⁸⁸

Urinary incontinence is the most prevalent symptom of pelvic floor dysfunction. The most common form of urinary incontinence is stress urinary incontinence, which is the involuntary loss of urine during an effort or physical exertion or on sneezing and coughing.⁸⁹ Studies that require high adherence to a strength training protocol and close follow-up indicate that pelvic floor muscle training after delivery can prevent and treat urinary incontinence.*⁹⁰

* The performance of pelvic floor exercises during pregnancy also has been shown to have a protective effect against postpartum urinary incontinence for 6 weeks and 3 months postpartum. Lemos, et al., 878.

Although pelvic floor muscle training can treat pelvic floor dysfunction and successfully reduce symptoms, pelvic floor muscle training necessitates the ability to perform properly a pelvic floor muscle contraction. An effective pelvic floor muscle contraction is one that increases urethral closure pressure without a substantial Valsalva effort; it involves an inward lift and squeeze around the urethra with resultant closure, stabilization, and resistance to downward movement.⁹¹ However, in a population exhibiting urinary incontinence, fecal incontinence, or prolapse, only 38 percent of women could perform an optimal pelvic floor muscle contraction. When attempting to perform a lifting contraction, 43 percent of women depressed the levator plate and 19 percent exhibited no change in levator plate position.⁹² This observation means that elevation of the levator plate is not the automatic response to verbal instruction to contract the pelvic floor. Additionally, women who depress the levator plate when attempting to perform a lifting contraction are actually weakening the pelvic ligaments and thereby contributing to the pathology of stress urinary incontinence and pelvic organ prolapse.⁹³ Such responses demonstrate the importance of education even in women who believe they know how to perform a correct pelvic floor muscle contraction.

Physiological/Morphological Implications for Postpartum Rehabilitation

During the puerperium, or approximately the first six weeks following delivery, women may start frequent sessions of sustained exercise and gradually increase exercise volume, i.e., intensity and duration, over time. Many women resume some form of exercise within two weeks after childbirth. If a woman experienced caesarean birth or traumatic vaginal birth, she may need to wait four weeks or longer before resuming exercise. During this initial stage, exercise should serve to provide relaxation and enhance well-being. While the body is undergoing its greatest extent of recovery from pregnancy and childbirth, progress in an exercise regimen is

irrelevant. Walking is the ideal exercise, but other forms of low-impact cardiovascular exercise such as swimming or cycling may also be permissible depending on the woman's birthing circumstances. Physicians recommend exercising at least three days a week; however, five times a week is ideal. If a woman's exercise does not provide relaxation or promote well-being or if it results in exercise-associated pain or heavy bleeding, she should revise her exercise program to reduce its frequency or volume. Additionally, the woman must ensure she maintains proper hydration and obtains adequate rest. The three absolute contraindications to exercise during the puerperium are heavy bleeding, pain, and infection or abscess. Women should also reduce breast discomfort by nursing or relieving engorgement prior to exercise and ensuring adequate breast support during exercise. While not complete contraindications to exercise, urine leakage and increased pelvic pressure during exercise are cues that a given activity is too intense.⁹⁴

As previously discussed, women who are sedentary in the antenatal period, either by choice or by medical necessity, undergo cardiovascular detraining during their sedentary period. Conversely, women who maintain at least a moderate exercise regimen can maintain or increase their absolute maximal aerobic capacity.⁹⁵ In either case, resumption of aerobic exercise following childbirth does not present inherent cardiovascular risk. Women should start with light- to moderate-intensity* aerobic exercise in terms of perceived exertion, particularly in the case of deconditioned women, and gradually increase exercise intensity and duration following the guidelines in the preceding paragraph. Because research supports the value of discontinuous exercise patterns, women may accumulate bouts of aerobic activity lasting at least 10 minutes throughout the course of the day and still obtain well-being and health benefits.⁹⁶

* Light intensity, as described by the American College of Sports Medicine (ACSM), equates to Borg rating of perceived exertion (RPE) 9-11 (very light to fairly light); moderate intensity corresponds to Borg RPE 12-13 (fairly light to somewhat hard).

Although a given activity may be safe in terms of cardiovascular risk, not all aerobic activities or anaerobic exercises are advisable in the immediate postpartum period for other reasons. High-impact activities such as running and jumping can place undue strain on weakened pelvic floor muscles and lax pelvic floor fascia, thereby leading to or exacerbating pelvic floor dysfunction. High-intensity, high-impact activities such as interval training, hill training, or activities that involve rapid direction change place even greater strain on pelvic floor structures.⁹⁷

The most suitable aerobic exercise for at least the first 3 weeks postpartum is walking. Once the flow of lochia has subsided, a woman can resume swimming or low intensity water aerobics. Once she has healed sufficiently to be comfortable sitting on a bicycle seat, a woman may resume cycling. Specifically in the case of cycling, the seat provides support to the pelvic floor. After the routine 6-week postnatal physical examination, provided the outcome is favorable, a woman may safely begin low impact aerobics training. During the third month postpartum, the woman ideally should be evaluated by a physical therapist and subjected to abdominal muscle and pelvic floor testing before introducing high-impact exercise. Generally, at approximately 4 months postpartum it should be safe to introduce high-impact exercise. This statement means that at approximately 4 months postpartum a woman can start running. It does not mean that she has sufficient pelvic floor and abdominal muscle strength to begin sprinting and conducting high-intensity interval training. Upon introducing high-impact activities, the woman should reduce the intensity of her training or change the nature of her activity if she leaks urine or senses pelvic floor muscle weakness or bouncing. Once she can engage in a given activity without experiencing pelvic floor weakness or dysfunction, she may gradually increase the intensity of her activity.⁹⁸ By 9 months postpartum, the woman should be able to conduct

intense interval training and hill training without experiencing feelings of weakness in the pelvic floor.⁹⁹

This prescribed guidance and the associated timeline regarding resumption of cardiovascular training assumes initiation of a graduated, progressive abdominal and pelvic floor muscle training program during the immediate postpartum period. In addition to accounting for pregnancy-induced and labor- and delivery-induced changes in abdominal musculature and pelvic floor structures, these guidelines consider the 3- to 5-month timeline for postpartum joint laxity resolution.

In terms of muscular fitness, the woman should begin performing transverse abdominal contractions and pelvic floor exercises shortly after delivery. After her 6-week postnatal check-up, again presuming favorable outcome, she may resume resistance training with light weights. She must be able to maintain good posture and form throughout a given activity.¹⁰⁰ When an exercise is difficult, the individual performing the exercise may not follow correct performance techniques.¹⁰¹ Additionally, she should not lift anything so heavy or perform a task so challenging that it requires straining or breath holding.¹⁰² Straining or holding one's breath increases intra-abdominal pressure, thereby stressing the core musculature,* including the transversus abdominis and the pelvic floor muscles, that manages such pressure. In addition to beginning with lighter weights, she should be sure to lift her pelvic floor before exerting effort and relax the pelvic floor afterwards. She should remain mindful of pelvic floor and transversus abdominis fatigue and reduce repetitions or increase rest as required. Reducing the depth of lunges or squats to keep hips higher than knees and using supported or seated positions also helps protect the pelvic floor as core muscle fitness improves. Over time, the woman may

* The core muscles include the diaphragm, the multifidus (extends up the spine), the transversus abdominis, and the pelvic floor.

gradually increase weight, number of repetitions at a given weight, and depths of squats or lunges. She also will be able gradually to introduce more demanding core exercises.¹⁰³

To increase safely the degree of impact, intensity, or difficulty associated with cardiovascular or muscular fitness training, the postpartum woman must engage in a graduated abdominal and pelvic floor muscle training program. The typical abdominal exercise regimen predominantly involves exercises that involve trunk flexion, such as sit-ups or crunches. Such rehabilitation programs are problematic because they preferentially train the rectus abdominis and neglect the deeper abdominal muscles that function as stabilizers and help manage intra-abdominal pressure. The increased activity of the rectus abdominis during trunk flexion exercises overrides the static holding capacity of transversus abdominis and internal oblique muscles. Furthermore, the higher the level of speed at which trunk flexion exercises are performed, the greater the reduction of abdominal stabilizing function.¹⁰⁴ Additionally, the trunk flexion exercises relied upon in traditional abdominal exercise programs increase intra-abdominal pressure.¹⁰⁵ When activities that increase intra-abdominal pressure, such as trunk flexion or heavy lifting, are introduced before the deep abdominal and pelvic floor muscles are adequately strengthened, the woman's inability to engage those muscles to control the pressure increase can lead to incidence or recurrence of diastasis recti, abdominal fascia herniation, urinary or fecal incontinence, and/or pelvic organ prolapse.¹⁰⁶

In order to train the deep core muscles, the transversus abdominis and pelvic floor should be trained progressively prior to introducing exercises that involve rectus abdominis contraction. Over time and following a graduated abdominal and pelvic floor muscle training program, postpartum women can learn to engage the transversus abdominis and pelvic floor and maintain the engagement as they lift their head and shoulders from a hook-lying position. With

progressive training, women can lift their head and shoulders higher, do more repetitions, and move their hands to positions that make the activity more demanding.¹⁰⁷ Presuming a woman starts her transversus abdominal and pelvic floor training during the immediate postpartum period, she should be safe to introduce a crunch or sit-up activity at approximately 6 months postpartum.¹⁰⁸

The PFT and CFT clearly include high-impact events. Additionally, due to the way in which events are evaluated, every test event is high-intensity. The participant must execute maximum repetitions, either without or within a time limit, and the participant must cover prescribed distances or perform prescribed activities in as little time as possible.¹⁰⁹ Such impact and intensity place substantial demands on the transversus abdominis and pelvic floor. Within the PFT, executing a maximum set of crunches in a 2-minute period is particularly demanding because it requires the Marine to perform high repetitions of crunches and to perform those repetitions at a high rate of speed. Even in isolation, these two requirements, high numbers of repetitions and high rates of speed, reduce the ability of the transverse abdominis and oblique muscles to perform a stabilizing function.

Proper rehabilitation prior to resuming fitness testing is important particularly in the case of the PFT crunch event. As discussed in the “Postpartum Physiology and Morphology” section, the inter-recti distance in postpartum women does not recover to nulliparous values even at 6 months postpartum, and the increased linea alba width correlates with abdominal functional deficit. While the degree to which abdominal exercise can reduce the inter-recti distance is unclear,¹¹⁰ physical therapy treatment can enable postpartum women to restore optimal strategies for transferring loads through the abdominal canister irrespective of diastasis recti closure.¹¹¹

Trunk flexion activities are specifically contraindicated during the immediate postpartum period, and they remain unsuitable until the transversus abdominis and pelvic floor are sufficiently strengthened to contain the increase in intra-abdominal pressure associated with the activity. Approximately 6 months postpartum is a reasonable point to expect the majority of women to be able to introduce a crunch activity. “Introduce” means that the woman is doing the activity for the first time. The postpartum woman will then have to build up progressively to performing more sets throughout the day and higher numbers of repetitions within a given set before she safely will be able to continue the activity for a 2-minute time period at a high rate of speed.

Although no one specific research study answers the question of how long it takes to progress sufficiently before a postpartum woman is physically capable of safely executing a maximum set of crunches in 2 minutes, physical therapists suggest approximately 9 months as sufficient based on their clinical observations.¹¹² Ideally, each woman should be evaluated individually by a women’s health physical therapist and cleared to undergo fitness testing based on her individual progress.¹¹³ However, having a prescribed timeline that captures the majority of the postpartum population provides a general guideline to postpartum women and health care providers and forces a trigger to assess whether women are making sufficient progress towards rehabilitation, if they need more time (i.e., an extension before resuming testing), or if their medical situation precludes further service. The 9-month timeline recommendation affords the majority of postpartum women sufficient time to rehabilitate in order to perform the crunch event safely.

Antenatal and postpartum physiology and morphology have substantial implications for postpartum rehabilitation. In the case of postpartum Marines, these implications mean that although postpartum Marines generally return to full duty at 6 weeks postpartum, they have not

sufficiently recovered to be able to perform the complete spectrum of full duty activities. They must progressively introduce those activities that are more demanding, particularly for core musculature. The rehabilitation process also determines at what point postpartum Marines are ready to resume fitness testing safely. If a woman begins a graduated abdominal and pelvic floor muscle training program by 6 weeks postpartum, she should be able to perform safely high-intensity, high-impact activities and execute properly repetitive trunk flexion activities by 9 months postpartum.

Recovery Resources

By and large, pregnant and postpartum women do not know what they do not know regarding postpartum rehabilitation. While MCCS provides limited pregnancy and parenthood training, it does not cover material specific to postpartum rehabilitation. Military hospitals hold voluntary classes that women can attend at 28 weeks and 36 weeks gestation, and they provide breastfeeding training, but these sessions do not discuss maternal care as it pertains to postpartum fitness. As a result, anything a woman learns during pregnancy or after delivery about postpartum rehabilitation is self-taught. However, because she does not know what she does not know, she may have difficulty discerning the accuracy or relevancy of self-acquired information.

Beyond pregnant and postpartum Marines, many commanding officer and OICs, particularly those who have never been pregnant, do not understand antenatal or postpartum physiology and morphology. Those who do understand pregnancy-induced changes still may lack an appreciation of the implications such changes have for postpartum rehabilitation. For commanding officers and OICs who have experienced pregnancy, that experience, in and of itself, does not inherently confer any expertise regarding safe or proper postpartum rehabilitation.

While the MCPFP informs commanders and OICs that postpartum Marines require a progressive training routine to return to prepregnancy fitness levels, the order provides no further information or additional details.¹¹⁴ In terms of educating Marines, the pregnancy and parenthood order only requires commanders to provide training on the contents of the order itself.¹¹⁵ As such, commanders have no requirement or means to educate themselves on postpartum rehabilitation considerations. Because they generally lack education regarding postpartum rehabilitation, most commanders are unable to serve as an educational resource to postpartum Marines. Senior enlisted leaders and other staff non-commissioned officers have the same educational deficits.

Per the MCPFP, as mentioned in the “Current Marine Corps Policies” section, a unit’s RCP provides tailored physical training for Marines whose fitness level has been degraded due to pregnancy, among other causes. The unit’s assigned combat conditioning instructor (CCI) or command physical training representative (CPTR) develops RCP training plans in accordance with Marine Corps Reference Publication (MCRP) 3-02A, *Marine Physical Readiness Training for Combat* and based on organizational mission essential tasks, applicable occupation-specific requirements, and individual identified deficiencies.¹¹⁶ While the CCI should have attended a CCI course, CCIs and CPTRs are required by the MCPFP only to review MCRP 3-02A and the MCPFP order itself.¹¹⁷ Neither the CCI course, the reference publication, nor the order provides training or education sufficient to qualify the CCI or CPTR to rehabilitate postpartum Marines.¹¹⁸ As such, the RCP is not an appropriate recovery resource regardless of how well-intentioned the responsible CCI or CPTR may be.

In addition to CCIs and CPTRs, most Semper Fit personal trainers are similarly unqualified to rehabilitate postpartum Marines despite their certification as personal trainers. The Semper Fit program does not maintain expertise in postpartum rehabilitation within its

personal trainer staff. A given personal trainer may choose independently to pursue education specific to postpartum rehabilitation, but the personal trainers have no requirement or incentive to do so. Additionally, personal trainers who pursue pregnancy and postpartum fitness training via continuing education may only have to attend a weekend seminar, many of which focus predominantly on pregnancy fitness and neglect or barely cover postpartum concerns.* As such, having a personal trainer with genuine expertise in postpartum rehabilitation is the exception rather than the norm at a given installation.

Physical therapy is the resource best suited to postpartum rehabilitation. Although pregnancy and childbirth should not be conflated with injury, vaginal delivery should be treated comparably to a major sports injury.¹¹⁹ Additionally, caesarian section, although common, is not minor surgery. The vast majority of bases and stations have physical therapy clinics. Although a small percentage of civilian physical therapists are board-certified, approximately 60 to 70 percent of military physical therapists are board-certified. Most board-certified military physical therapists specialize in either orthopaedics or sports, but the military does have some women's health specialists. A physical therapist who is certified in women's health is best suited to assess the degree of abdominal separation and pelvic floor damage, as well as any joint or alignment issues, and to determine individual functional deficits; however, sports specialists have a component of their certification on understanding women in sports that would qualify them to conduct a similar evaluation. Such evaluation enables the physical therapist to develop an individualized progressive graduated rehabilitation program. If a given physical therapist at a

* The book provided for Aerobics and Fitness Association of America's Perinatal Fitness weekend workshop has 84 pages, 2 of which address postpartum fitness. Aerobics and Fitness Association of America. *Perinatal Fitness: Fitness during the Childbearing Year—Pregnancy, Birth, and Postpartum*. Sherman Oaks, CA: Aerobics and Fitness Association of America, 2005, workshop manual.

particular military treatment facility is presented with a postpartum case that exceeds their level of expertise, the physical therapist has the ability to refer that patient to a local civilian facility.¹²⁰

Reconciling Policy with Biology

This section is entitled “Reconciling Policy with Biology” because the Marine Corps can reconcile policy with biology, but biology cannot adapt to fit policy. Bypassing biology, while a potential option, is not a viable option. Policy should not define pregnancy or motherhood as incompatible with service.

As stated in the “Current Marine Corps Policies” section, the current policy regarding resumption of fitness testing is based on the assertion that the physiological effects of pregnancy have resolved by the sixth week postpartum and that it is physiologically feasible to achieve sufficient physical fitness over the course of a 6-month period to complete a fitness test successfully.¹²¹ This assertion is flawed in a couple of ways. First, the ACOG guidelines that informed the current policy actually state that “many of the physiologic and morphologic changes of pregnancy persist 4-6 weeks postpartum.”¹²² That statement does not equate to the current policy’s justification that all of the physiological effects of pregnancy resolve by 6 weeks postpartum. Not only does the ACOG not assert such complete resolution, but the section on “Postpartum Physiology and Morphology” clearly shows that the effects of pregnancy do not resolve by 6 weeks postpartum. Moreover, some changes persist permanently, while others have yet to resolve by 6 or 12 months postpartum. Second, because of the flawed assumption regarding the first 6 weeks postpartum, the assertion that 6 additional months is enough time to regain sufficient fitness assumes that the postpartum Marine’s baseline at 6 weeks postpartum is merely a detrained state rather than a state of physiological and morphological deficit that must be progressively overcome.

As shown through the sections that detailed antenatal and postpartum physiology and morphology and that discussed their implications for postpartum rehabilitation, six months following return to full duty is an insufficient length of time to recover properly and resume fitness testing safely. Rather, the current timeline for resumption of fitness testing should be extended to no earlier than 9 months postpartum.

However, nine months is a sufficient length of time to rehabilitate only if women have access to appropriate resources to facilitate their recovery. The Marine's primary care manager, obstetrician, or another health care provider should refer the postpartum Marine for physical therapy either prior to childbirth or upon discharge from the hospital or birthing facility following delivery. This referral timeline would enable the woman to schedule an initial appointment shortly after discharge. Having an initial evaluation prior to return to full duty would enable the physical therapist to conduct an initial assessment of any pelvic floor damage and provide instruction to the postpartum Marine on the performance of pelvic floor and transversus abdominis exercises to be conducted during the immediate postpartum period before she returns to work. Ideally, the physical therapist should be a women's health specialist; however, a sports specialist does have a component regarding understanding women in sports. Whether military or civilian, physical therapists who work in military care facilities but lack women's health or sports board-certification should receive women's health training specifically regarding postpartum or pelvic physical therapy so that they can adequately rehabilitate postpartum patients.

Although not a direct requisite for reconciling policy with biology, education plays an important role in policy implementation. As discussed in the "Recovery Resources" section, pregnant and postpartum Marines and Marine leaders have limited resources available to provide

education regarding the implications of antenatal and postpartum physiology and morphology for physical training and fitness testing. In the case of pregnant and postpartum Marines, the physical therapist to whom she is referred can provide adequate education, training, and guidance to direct and support her rehabilitation. To address the lack of educational resources for commanders and other Marine leaders, adding a brief explanatory paragraph to the MCPFP in order to better clarify and describe the postpartum rehabilitation process would be a relatively simple way to provide more information and a greater degree of expectations management without levying an additional training requirement. Currently, the MCPFP only includes the following addendum sentence to serve as a caveat at the end of paragraph 6.f.(2) in Chapter 1: “Commanders/OICs should be attentive that Marines returning to full duty status following pregnancy will require a progressive training routine in returning to the level of fitness experience prior to pregnancy.”¹²³ This sentence is inadequate in terms of providing commanders and Marine leaders an appreciation of the rehabilitation process and should be replaced with a separate numbered subparagraph within paragraph 6.f. that concisely explains why postpartum fitness must be graduated and progressive. The addition to the order should also indicate that although the postpartum Marine typically returns to full duty following her convalescent leave, she is not yet ready to perform the complete spectrum of full duty activities, particularly combat conditioning or physical training activities. If a commander or Marine leader desires more extensive education regarding postpartum rehabilitation, that leader can consult a qualified physical therapist. Additionally, socialization of postpartum rehabilitation concerns by Marine leaders and Marine mothers will raise service-wide awareness over time.

Despite the extent of information currently available regarding postpartum rehabilitation, reconciling policy with biology should remain an iterative process. In the case of endocrine

changes, the current body of research does not examine the degree to which the influence of pregnancy hormones persists following delivery. Particularly in the case of lactating women, research has not considered the impact of the hormones that maintain lactation on ligament relaxation. Once further studies regarding joint laxity in lactating women are conducted, the Marine Corps will have the responsibility to reexamine postpartum fitness testing guidelines to ensure that they are still relevant to breastfeeding mothers. While breastfeeding women likely can progress safely along the recommended 9-month postpartum rehabilitation timeline, any extended joint laxity persistence in their case makes graduated rehabilitation and mastery of optimal load transfer strategies even more essential to long-term recovery.

Conclusion

Things do not just go back to normal following childbirth, and that reality has compelling implications for resumption of fitness testing. Although no one specific research study answers the question of how much time a postpartum woman needs to rehabilitate sufficiently before she is physically capable of safely completing a fitness test, an analysis of the body of research, reported clinical observations, and the rehabilitation process clearly shows the insufficiency of current Marine Corps policy. Six months following return to full duty, or approximately seven and a half months, is not enough time to regain sufficient muscular strength and endurance, particularly in transversus abdominis and pelvic floor musculature, to be able to perform high-intensity, high-impact activities and sustained repetitive trunk flexion activities. Postpartum Marines should, however, be able safely to complete a fitness test at 9 months postpartum as long as they begin a graduated physical therapy program shortly after delivery to regain core strength. Like all other Marines, postpartum Marines are athletes, but they need time and appropriate resources to be able to rehabilitate properly. If they are not afforded sufficient time

or appropriate resources to rehabilitate properly, they risk incidence or recurrence of diastasis recti, abdominal fascia herniation, urinary and fecal incontinence, and/or pelvic organ prolapse. If the Marine Corps makes the nine-month short-term investment in its postpartum Marines, it will improve the long-term health and readiness of its postpartum population.

The Marine Corps has a responsibility to pursue genuine reconciliation of policy to biology in matters where biology is compatible with continued service. This paper's comprehensive review and analysis presents a compelling case for its two primary policy recommendations. However, if Marine decision-makers deem this presentation insufficiently compelling or inadequate to inform a policy change, the Marine Corps has a responsibility to pursue an objective study of its own pregnant and postpartum populations to augment the current body of research.* Whether Marine decision-makers embrace this paper's thesis, the proponents of the MCPFP and the pregnancy and parenthood order need to continue the revisions they began when Training and Education Command wrote MARADMIN 005/15 in order to obtain parity within and across the two orders.†

* To date, no studies have been published that in any way examine postpartum rehabilitation in Marine populations. Three studies related to fitness test performance have been published on postpartum military populations; two of these looked at Air Force sample populations and one at an Army population. These three studies in no way measured any variables that would assess whether women had rehabilitated sufficiently or improved core musculature function adequately to ensure safe testing. Nicole H. Armitage and Denise A. Smart, "Changes in Air Force Fitness Measurements Pre- and Post-Childbirth," *Military Medicine* 177, no. 12 (December 2012): 1519-1523; Nicole H. Armitage, Billie M. Severtsen, Roxanne Vandemaese, and Denise A. Smart, "Training for the Air Force Fitness Assessment: The Experience of Postpartum Women," *Military Medicine* 179, no. 7 (July 2014): 766-772; and Stacy Usher Weina, "Effects of Pregnancy on the Army Physical Fitness Test," *Military Medicine* 171, no. 6 (June 2006): 534-537.

† Currently, the pregnancy and parenthood order is undergoing revision by the Manpower Plans and Policy Division at Manpower & Reserve Affairs.

APPENDIX A: POSTPARTUM RECOVER RESOURCES

The resources listed below provide general information and are not a substitute for individualized medical advice or prescribed treatment.

Ryan, Marianne. *Baby Bod®: Turn Flab into Fab in 12 Weeks Flat*. Edited by Deborah Grandinetti. Forthcoming.

Marianne Ryan is a prominent prenatal and postpartum physical therapist and clinical director in New York, NY. This book's release is tentatively scheduled for late April 2015. Although this book has an informal title, it is the product of thorough research by the author. Ryan successfully communicates technical concepts and explanations in layman's terms so that they can be widely understood and applied.

The Pregnancy Centre. "Postnatal Exercises." *The Pregnancy Centre*, last modified 2015.

<http://www.thepregnancycentre.com.au/post-pregnancy/exercise/postnatal-exercises>. This website provides graduated core exercise levels developed by Dianne Edmonds, Director and Founder of The Pregnancy Centre in Australia. The exercises that comprise each level include photos and detailed descriptions. The levels are loosely tied to weeks postpartum ranging from 0-24 weeks. In addition to the timeline, each subsequent level's page provides guidelines to help determine individual readiness to advance to that given level.

Notes

¹ Brian McGuire (Physical Readiness Programs Officer, Marine Air-Ground Task Force Training and Education Standards Division, Training and Education Command), interviewed by author, January 28, 2015 at 1000.

² Commandant of the Marine Corps, *Marine Corps Policy Concerning Pregnancy and Parenthood*, MCO 5000.12E W/CH 1-2, December 8, 2004., 3, 10, <http://www.marines.mil/Portals/59/Publications/MCO%205000.12E%20W%20CH%201-2.pdf>.

³ CMC, *Pregnancy and Parenthood*, 3.

⁴ CMC, *Pregnancy and Parenthood*, 3, 5, 8.

⁵ CMC, *Pregnancy and Parenthood*, 3-4.

⁶ Commandant of the Marine Corps, *Marine Corps Physical Fitness Program*, MCO 6100.13 W/CH 1, August 1, 2008, 1-8,

http://www.marines.mil/Portals/59/Publications/MCO%206100.13%20W_CH%201.pdf.

⁷ CMC, *MCPFP*, 1-8.

⁸ CMC, *MCPFP*, 1-8, 1-12.

⁹ Commanding General, Training and Education Command, *Change 2 to MCO 6100.13 Marine Corps Physical Fitness Program*, MARADMIN 005/15, January 6, 2015,

<http://www.marines.mil/News/Messages/MessagesDisplay/tabid/13286/Article/172743/change-2-to-mco-610013-marine-corps-physical-fitness-program.aspx>.

¹⁰ “Health Services, Headquarters Marine Corps,” *Marines: The Official Website of the United States Marine Corps*, accessed on February 25, 2015,

<http://www.hqmc.marines.mil/Agencies/HealthServices/DirectorofPsychologicalHealth.aspx>.

¹¹ Prior to providing input, CAPT Vincent L. DeCicco, Director of Clinical Programs, Health Services, Headquarters Marine Corps additionally consulted current guidelines from the American Academy of Pediatrics (AAP), American Academy of Family Physicians (AAFP), and US Preventative Services Task Force (USPSTF); however, only the ACOG provided information specific to the postpartum period. CAPT Vincent L. DeCicco, USN, Director of Clinical Programs, Health Services, Headquarters Marine Corps, “Review and Update of MCO 5000.12E (Marine Corps Policy Concerning Pregnancy and Parenthood),” information memorandum excerpt, April 24, 2014.

¹² CAPT Vincent L. DeCicco, information memorandum excerpt.

¹³ CMC, *MCPFP*, 1-8.

¹⁴ CMC, *MCPFP*, 4-1.

¹⁵ CMC, *MCPFP*, 2-2 to 2-7.

¹⁶ CMC, *MCPFP*, 3-2 to 3-8.

¹⁷ Gary F. Cunningham, et al., ed., *Williams Obstetrics*, 24th ed. (New York: McGraw-Hill Education, 2014), 55.

¹⁸ Cunningham, et al., 58.

¹⁹ James F. Clapp III and Catherine Cram, *Exercising Through Your Pregnancy*, 2nd ed. (Omaha, NB: Addicus Books, Inc., 2012), nook book, 13-14.

²⁰ Cunningham, et al., 62.

²¹ Cunningham, et al., 63.

²² Clapp III and Cram, 10.

- ²³ Kristin Reimers Kardel, "Effects of Intense Training during and after Pregnancy in Top-Level Athletes," *Scandinavian Journal of Medicine and Science in Sports* 15, no. 2 (April 2005): 84.
- ²⁴ Clapp III and Cram, 62.
- ²⁵ Clapp III and Cram, 53-61.
- ²⁶ M. L. Marnach, et al., "Characterization of the Relationship Between Joint Laxity and Maternal Hormones in Pregnancy," *Obstetrics and Gynecology* 101, no. 2 (February 2003): 332-335.
- ²⁷ Diane G. Lee and Linda-Joy Lee, *The Pelvic Girdle: An Integration of Clinical Expertise and Research*, 4th ed. (London: Churchill Livingstone, 2011), 138.
- ²⁸ C. M. Norris, "Abdominal Muscle Training in Sport," *British Journal of Sports Medicine* 27, no. 1 (1993): 19, <http://bjsm.bmj.com/>.
- ²⁹ Diane G. Lee, Linda-Joy Lee, and L. McLaughlin, "Stability, Continence and Breathing: The Role of Fascia Following Pregnancy and Delivery," *Journal of Bodywork and Movement Therapies* 12, no. 4 (October 2008): 334, <http://ncbi.nlm.gov/pubmed/19083692>.
- ³⁰ Norris, 20.
- ³¹ Richard S. Jemmett, *Spinal Stabilization: The New Science of Back Pain*, 2nd ed. (Canada: Libris Hubris Publishing, 2013), 14.
- ³² Lih-Jiun Liaw, et al., "The Relationships Between Inter-recti Distance Measured by Ultrasound Imaging and Abdominal Muscle Function in Postpartum Women: A 6-Month Follow-up Study," *Journal of Orthopaedic & Sports Physical Therapy* 41, no. 6 (June 2011): 441, www.jospt.org.
- ³³ Wendy L. Gilleard and J. Mark M. Brown, "Structure and Function of the Abdominal Muscles in Primigravid Subjects During Pregnancy and the Immediate Postbirth Period," *Physical Therapy* 76, no. 7 (July 1996): 755, <http://ptjournal.apta.org/content/76/7/750>.
- ³⁴ Gilleard and Brown, 758.
- ³⁵ Yvonne Coldron, et al., "Postpartum Characteristics of Rectus Abdominis on Ultrasound Imaging," *Manual Therapy* 13, no. 2 (May 2008): 116-117.
- ³⁶ Coldron, et al., 116-117.
- ³⁷ Gilleard and Brown, 756.
- ³⁸ Gilleard and Brown, 758.
- ³⁹ Gilleard and Brown, 757.
- ⁴⁰ Gilleard and Brown, 757.
- ⁴¹ Gilleard and Brown, 761.
- ⁴² D. R. Benjamin, A. T. M. van de Water, and C. L. Peiris, "Effects of Exercise on Diastasis of the Rectus Abdominis Muscle in the Antenatal and Postnatal Periods: A Systematic Review," *Physiotherapy* 100, no. 1 (March 2014): 1.
- ⁴³ Gilleard and Brown, 756.
- ⁴⁴ P. G. Mota, et al., "Prevalence and Risk Factors of Diastasis Recti Abdominis from Late Pregnancy to 6 Months Postpartum, and Relationship with Lumbo-Pelvic Pain," *Manual Therapy* 20, no. 1 (February 2015): 202.
- ⁴⁵ Diane G. Lee and Linda-Joy Lee, 38.
- ⁴⁶ Dot Stables and Jean Rankin, ed., *Physiology in Childbearing: With Anatomy and Related Biosciences*, 3rd ed. (New York: Baillière Tindall, 2010), 356.

- ⁴⁷ Andrea Lemos, et al., “Do Perineal Exercises during Pregnancy Prevent the Development of Urinary Incontinence? A Systematic Review,” *International Journal of Urology* 15 (2008): 875.
- ⁴⁸ Lee, Lee, and McLaughlin, 337.
- ⁴⁹ Siv Mørkved and Kari Bø, “Effect of Pelvic Floor Muscle Training during Pregnancy and after Childbirth on Prevention and Treatment of Urinary Incontinence: A Systematic Review,” *British Journal of Sports Medicine* 48, no. 4 (February 2014): 1, <http://bjsm.bmj.com/>.
- ⁵⁰ Lee and Lee, 133-134.
- ⁵¹ Lee and Lee, 141-142.
- ⁵² Lee and Lee, 134-137.
- ⁵³ Lee and Lee, 139-140.
- ⁵⁴ Cunningham, et al., 668 and Steven G. Gabbe, et al., *Obstetrics: Normal and Problem Pregnancies*, 6th ed. (Philadelphia, PA: Saunders, 2012), 517.
- ⁵⁵ Gabbe, et al., 517.
- ⁵⁶ Cunningham, et al., 669 and Gabbe, et al., 517-518.
- ⁵⁷ Cunningham, et al., 670 and Gabbe, et al., 518.
- ⁵⁸ Cunningham, et al., 671.
- ⁵⁹ Gabbe, et al., 520.
- ⁶⁰ Kardel, 84.
- ⁶¹ Clapp III and Cram, 18.
- ⁶² James F. Clapp III and Eleanor Capeless, “The VO_{2max} of Recreational Athletes before and after Pregnancy,” *Medicine and Science in Sports and Exercise* 23, no. 10 (October 1991): 1131.
- ⁶³ Clapp III and Cram, 18.
- ⁶⁴ Marnach, et al., 332.
- ⁶⁵ Cunningham, et al., 71.
- ⁶⁶ Marianne Ryan, *Baby Bod®: Turn Flab into Fab in 12 Weeks Flat*, ed. by Deborah Grandinetti, forthcoming, chapter 5, pages 7-8.
- ⁶⁷ Ryan, chapter 5, page 7.
- ⁶⁸ Gilleard and Brown, 758.
- ⁶⁹ Coldron, et al., 116-117.
- ⁷⁰ Coldron, et al., 120.
- ⁷¹ Gilleard and Brown, 756.
- ⁷² Gilleard and Brown, 761.
- ⁷³ Liaw, et al., 441.
- ⁷⁴ Coldron, et al., 116-117.
- ⁷⁵ Liaw, et al., 442.
- ⁷⁶ Coldron, et al., 120.
- ⁷⁷ Liaw, et al., 436.
- ⁷⁸ Benjamin, van de Water, and Peiris, 7.
- ⁷⁹ Lee, Lee, and McLaughlin, 336.
- ⁸⁰ Mota, et al., 202; Gail S. Bursch, “Interrater Reliability of Diastasis Recti Abdominis Measurement,” *Physical Therapy* 67 (July 1987): 1078-1079, <http://ptjournal.apta.org/content/67/7/1077>; Jill Schiff Boissonnault and Mary Jo Blaschak, “Incidence of Diastasis Recti Abdominis during the Childbearing Year,” *Physical Therapy* 68, no. 7 (July 1988): 1085, <http://ptjournal.apta.org/content/68/7/1082>; and T. M. Spitznagle, F. C.

Leong, and L. R. Van Dillen, "Prevalence of Diastasis Recti Abdominis in a Urogynecological Patient Population," *International Urogynecology Journal and Pelvic Floor Dysfunction* 18, no. 3 (March 2007): 321-328.

⁸¹ Mota, et al., 203.

⁸² Mota, et al., 203; Coldron, et al., 120; Benjamin, van de Water, and Peiris, 4; and R. Hannaford and J. Tozer, "An Investigation of the Incidence, Degree and Possible Predisposing Factors of Rectus Diastasis in the Immediate Postpartum Period," *The Journal of the National Obstetrical and Gynaecological Special Group of the Australian Physiotherapy Association* 4, no. 2 (1985): 29-34.

⁸³ Volkan Turan, et al., "Prevalence of Diastasis Recti Abdominis in the Population of Young Multiparous Adults in Turkey," *Ginekologia Polska* 82, no. 11 (November 2011): 819 and Hannaford and Tozer, 29-34.

⁸⁴ Lee and Lee, 141.

⁸⁵ Guri Rørtveit and Yngvild S. Hannestad, "Association between Mode of Delivery and Pelvic Floor Dysfunction," *Tidsskrift for den Norske Legeforening* 134, no. 19 (October 2014): 1848. <http://tidsskriftet.no/pdf/pdf2014/1848-52eng.pdf>.

⁸⁶ Rørtveit and Hannestad, 1849.

⁸⁷ Rørtveit and Hannestad, 1850-1851.

⁸⁸ C. Glazener, A. Elders, C. MacArthur, R. J. Lancashire, P. Herbison, S. Hagen, N. Dean, C. Bain, P. Toozs-Hobson, K. Richard, A. McDonald, G. McPherson, D. Wilson, "Childbirth and Prolapse: Long-Term Associations with the Symptoms and Objective Measurement of Pelvic Organ Prolapse," *BJOG: An International Journal of Obstetrics & Gynaecology* 120, no. 2 (January 2013): 164, <http://onlinelibrary.wiley.com/doi/10.1111/1471-0528.12075/pdf>.

⁸⁹ Mørkved and Bø, 1.

⁹⁰ Mørkved and Bø, 11.

⁹¹ Judith A. Thompson and Peter B. O'Sullivan, "Levator Plate Movement during Voluntary Pelvic Floor Muscle Contraction in Subjects with Incontinence and Prolapse: A Cross-Sectional Study and Review," *International Urogynecology Journal and Pelvic Floor Dysfunction* 14, no. 2 (June 2003): 84 and Judith A. Thompson, et al., "Differences in Muscle Activation Patterns during Pelvic Floor Muscle Contraction and Valsalva Manoeuvre," *Neurourology and Urodynamics* 25, no. 2 (2006): 148.

⁹² Thompson and O'Sullivan, 85-86.

⁹³ Thompson and O'Sullivan, 87.

⁹⁴ Clapp III and Cram, 101-108.

⁹⁵ Clapp III and Cram, 18.

⁹⁶ Carol Ewing Garber, et al., "Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise," ACSM position stand, *Medicine & Science in Sports & Exercise* 43, no. 7 (July 2011): 1336, 1339, 1344, 1348, http://journals.lww.com/acsm-msse/Fulltext/2011/07000/Quantity_and_Quality_of_Exercise_for_Developing.26.aspx.

⁹⁷ Continence Foundation of Australia, "Pelvic Floor Safe Cardio Exercises," *Pelvic Floor First*, last modified 2013, <http://www.pelvicfloorfirst.org.au/pages/what-are-pelvic-floor-safe-exercises.html> and Dianne Edmonds (Director and Founder of The Pregnancy Centre in Australia), e-mail message to author, January 13, 2015.

⁹⁸ Continnence Foundation of Australia, “Pelvic Floor Safe Cardio Exercises” and Continnence Foundation of Australia, “Returning to Sport or Exercise after the Birth,” *Pelvic Floor First*, last modified 2013, <http://www.pelvicfloorfirst.org.au/pages/returning-to-sport-or-exercise-after-the-birth.html>.

⁹⁹ Dianne Edmonds (Director and Founder of The Pregnancy Centre in Australia), e-mail message to author, January 13, 2015 and Dianne Edmonds, “Erica’s Story,” *The Pregnancy Centre*, last modified 2015. <http://www.thepregnancycentre.com.au/post-pregnancy/stories/erica-s-story>.

¹⁰⁰ Continnence Foundation of Australia, “Returning to Sport or Exercise after the Birth.”

¹⁰¹ Gilleard and Brown, 761.

¹⁰² Continnence Foundation of Australia, “Returning to Sport or Exercise after the Birth.”

¹⁰³ Continnence Foundation of Australia, “Pelvic Floor Safe Resistance Exercises,” *Pelvic Floor First*, last modified 2013, <http://www.pelvicfloorfirst.org.au/pages/pelvic-floor-safe-resistance-exercises.html>.

¹⁰⁴ Deborah Wohlfahrt, Gwendolen Jull, and Carolyn Richardson, “The Relationship between the Dynamic and Static Function of Abdominal Muscles,” *Australian Physiotherapy* 39, no. 1 (1993): 12.

¹⁰⁵ C. M. Norris, “Abdominal Muscle Training in Sport,” *British Journal of Sports Medicine* 27, no. 1 (1993): 24, <http://bjsm.bmj.com/>.

¹⁰⁶ Stables and Rankin, 356.

¹⁰⁷ Dianne Edmonds, *Postnatal Abdominal Rehabilitation* (New South Wales, Australia: Australian Fitness Network, 2012), 5, www.fitnessnetwork.com.au/cecs.

¹⁰⁸ Dianne Edmonds (Director and Founder of The Pregnancy Centre in Australia), e-mail message to author, January 5, 2015 and Judith Thompson (continence and women’s health physical therapist), e-mail to author, March 2, 2015.

¹⁰⁹ CMC, *MCPFP*, 2-2 to 2-4, 3-2 to 3-8.

¹¹⁰ Benjamin, van de Water, and Peiris, 7.

¹¹¹ Lee, Lee, and McLaughlin, 336.

¹¹² The author chose to consult two Australian physical therapists, Dianne Edmonds and Judith Thompson, because Australia is acknowledged, even by American physical therapists, to emphasize postpartum rehabilitation better than the United States. The author also consulted American physical therapists in the course of her research. Dianne Edmonds (Director and Founder of The Pregnancy Centre in Australia), e-mail message to author, January 5, 2015; Dianne Edmonds (Director and Founder of The Pregnancy Centre in Australia), e-mail message to author, January 13, 2015; and Judith Thompson (continence and women’s health physical therapist), e-mail to author, March 2, 2015.

¹¹³ Dianne Edmonds (Director and Founder of The Pregnancy Centre in Australia), e-mail message to author, January 5, 2015 and Marianne Ryan (prenatal and postpartum physical therapist and Clinical Director, Marianne Ryan Physical Therapy, New York, NY), interviewed by author, February, 19, 2015 at 1500.

¹¹⁴ CMC, *MCPFP*, 1-8.

¹¹⁵ CMC, *Pregnancy and Parenthood*, 3-4.

¹¹⁶ CMC, *MCPFP*, 1-2, 4-1.

¹¹⁷ CMC, *MCPFP*, 2, 1-2.

¹¹⁸ CMC, *MCPFP* and Commanding General, Marine Corps Combat Development Command, *Marine Physical Readiness Training for Combat*, MCRP 3-02A, June 16, 2004, https://ia600808.us.archive.org/18/items/milmanual-mcrp-3-02a-marine-physical-readiness-training-for-combat/mcrp_3-02a_marine_physical_readiness_training_for_combat.pdf.

¹¹⁹ Mørkved and Bø, 1.

¹²⁰ CAPT Michele Weinstein, USN (Department Head, Physical Therapy Department, David R. Ray Branch Health Clinic, The Basic School, Quantico, VA), interviewed by author, February 9, 2015 at 0700. CAPT Weinstein is board-certified in sports.

¹²¹ CAPT Vincent L. DeCicco, information memorandum excerpt.

¹²² American College of Obstetricians and Gynecologists, “Exercise during Pregnancy and the Postpartum Period,” *ACOG Committee Opinion*, no. 267, January 2002, reaffirmed 2009, 3, <http://www.acog.org/Resources-And-Publications/Committee-Opinions/Committee-on-Obstetric-Practice/Exercise-During-Pregnancy-and-the-Postpartum-Period>.

¹²³ CMC, *MCPFP*, 1-8.

Bibliography

- Aerobics and Fitness Association of America. *Perinatal Fitness: Fitness during the Childbearing Year—Pregnancy, Birth, and Postpartum*. Sherman Oaks, CA: Aerobics and Fitness Association of America, 2005, workshop manual.
- American College of Obstetricians and Gynecologists. “Exercise during Pregnancy and the Postpartum Period.” *ACOG Committee Opinion*, no. 267, January 2002, reaffirmed 2009. <http://www.acog.org/Resources-And-Publications/Committee-Opinions/Committee-on-Obstetric-Practice/Exercise-During-Pregnancy-and-the-Postpartum-Period>.
- Armitage, Nicole H. and Denise A. Smart. “Changes in Air Force Fitness Measurements Pre- and Post-Childbirth.” *Military Medicine* 177, no. 12 (December 2012): 1519-1523.
- Armitage, Nicole H., Billie M. Severtsen, Roxanne Vandemaase, and Denise A. Smart. “Training for the Air Force Fitness Assessment: The Experience of Postpartum Women.” *Military Medicine* 179, no. 7 (July 2014): 766-772.
- Benjamin, D. R., A. T. M. van de Water, and C. L. Peiris. “Effects of Exercise on Diastasis of the Rectus Abdominis Muscle in the Antenatal and Postnatal Periods: A Systematic Review.” *Physiotherapy* 100, no. 1 (March 2014): 1-8.
- Boissonnault, Jill Schiff and Mary Jo Blaschak. “Incidence of Diastasis Recti Abdominis during the Childbearing Year.” *Physical Therapy* 68, no. 7 (July 1988): 1082-1086. <http://ptjournal.apta.org/content/68/7/1082>.
- Bursch, S. Gail. “Interrater Reliability of Diastasis Recti Abdominis Measurement.” *Physical Therapy* 67 (July 1987): 1077-1079. <http://ptjournal.apta.org/content/67/7/1077>.
- Clapp, James F., III, and Eleanor Capeless. “Cardiovascular Function before, during, and after the First and Subsequent Pregnancies.” *The American Journal of Cardiology* 80, no. 11 (December 1, 1997): 1469-1473.
- Clapp, James F., III, and Eleanor Capeless. “The VO_{2max} of Recreational Athletes before and after Pregnancy.” *Medicine and Science in Sports and Exercise* 23, no. 10 (October 1991): 1128-1133.
- Clapp, James F., III, and Catherine Cram. *Exercising Through Your Pregnancy*. 2nd ed. Omaha, NB: Addicus Books, Inc., 2012, nook book.
- Coldron, Yvonne, Maria J. Stokes, Di J. Newham, and Katy Cook. “Postpartum Characteristics of Rectus Abdominis on Ultrasound Imaging.” *Manual Therapy* 13, no. 2 (May 2008): 112-121.

- Commandant of the Marine Corps. *Marine Corps Body Composition and Military Appearance Program*. MCO 61100.3 W/CH 1, August 8, 2008.
<http://www.marines.mil/Portals/59/Publications/MCO%206110.3%20W%20CH%201.pdf>.
- Commandant of the Marine Corps. *Marine Corps Physical Fitness Program*. MCO 6100.13 W/CH 1, August 1, 2008.
http://www.marines.mil/Portals/59/Publications/MCO%206100.13%20W_CH%201.pdf.
- Commandant of the Marine Corps. *Marine Corps Policy Concerning Pregnancy and Parenthood*. MCO 5000.12E W/CH 1-2, December 8, 2004.
<http://www.marines.mil/Portals/59/Publications/MCO%205000.12E%20W%20CH%201-2.pdf>.
- Commanding General, Marine Corps Combat Development Command. *Marine Physical Readiness Training for Combat*. MCRP 3-02A, June 16, 2004.
https://ia600808.us.archive.org/18/items/milmanual-mcrp-3-02a-marine-physical-readiness-training-for-combat/mcrp_3-02a_marine_physical_readiness_training_for_combat.pdf.
- Commanding General, Training and Education Command. *Change 2 to MCO 6100.13 Marine Corps Physical Fitness Program*. MARADMIN 005/15, January 6, 2015.
<http://www.marines.mil/News/Messages/MessagesDisplay/tabid/13286/Article/172743/change-2-to-mco-610013-marine-corps-physical-fitness-program.aspx>.
- Continence Foundation of Australia. “Pelvic Floor Safe Cardio Exercises.” *Pelvic Floor First*, last modified 2013. <http://www.pelvicfloorfirst.org.au/pages/what-are-pelvic-floor-safe-exercises.html>.
- Continence Foundation of Australia. “Pelvic Floor Safe Resistance Exercises.” *Pelvic Floor First*, last modified 2013. <http://www.pelvicfloorfirst.org.au/pages/pelvic-floor-safe-resistance-exercises.html>.
- Continence Foundation of Australia. “Returning to Sport or Exercise after the Birth.” *Pelvic Floor First*, last modified 2013. <http://www.pelvicfloorfirst.org.au/pages/returning-to-sport-or-exercise-after-the-birth.html>.
- Continence Foundation of Australia. “Signs of a Pelvic Floor Problem.” *Pelvic Floor First*, last modified 2013. <http://www.pelvicfloorfirst.org.au/pages/how-can-i-tell-if-i-have-a-pelvic-floor-problem.html>.
- Cunningham, F. Gary, Kenneth J. Leveno, Steven L. Bloom, Catherine Y. Spong, Jodi S. Dashe, Barbara L. Hoffman, Brian M. Casey, and Jeanne S. Sheffield, ed. *Williams Obstetrics*. 24th ed. New York: McGraw-Hill Education, 2014.

- DeCicco, CAPT Vincent L., USN, Director of Clinical Programs, Health Services, Headquarters Marine Corps. "Review and Update of MCO 5000.12E (Marine Corps Policy Concerning Pregnancy and Parenthood)," information memorandum excerpt, April 24, 2014.
- Edmonds, Dianne. *Postnatal Abdominal Rehabilitation*. New South Wales, Australia: Australian Fitness Network, 2012. www.fitnessnetwork.com.au/cecs.
- Gabbe, Steven G, Jennifer R. Niebyl, Joe Leigh Simpson, Mark B. Landon, Henry L. Galan, Eric R. M. Jauniaux, and Deborah A. Driscoll. *Obstetrics: Normal and Problem Pregnancies*. 6th ed. Philadelphia, PA: Saunders, 2012.
- Garber, Carol Ewing, Bryan Blissmer, Michael Deschenes, Barry A. Franklin, Michael J. Lamonte, I-Min M. D. Lee, David C. Nieman, David P. Swain. "Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise." ACSM position stand. *Medicine & Science in Sports & Exercise* 43, no. 7 (July 2011): 1334-1359. http://journals.lww.com/acsm-msse/Fulltext/2011/07000/Quantity_and_Quality_of_Exercise_for_Developing.26.aspx.
- Gilleard, Wendy L. and J. Mark M. Brown. "Structure and Function of the Abdominal Muscles in Primigravid Subjects During Pregnancy and the Immediate Postbirth Period." *Physical Therapy* 76, no. 7 (July 1996): 750-762. <http://ptjournal.apta.org/content/76/7/750>.
- Glazener, C., A. Elders, C. MacArthur, R. J. Lancashire, P. Herbison, S. Hagen, N. Dean, C. Bain, P. Toozs-Hobson, K. Richard, A. McDonald, G. McPherson, D. Wilson. "Childbirth and Prolapse: Long-Term Associations with the Symptoms and Objective Measurement of Pelvic Organ Prolapse." *BJOG: An International Journal of Obstetrics & Gynaecology* 120, no. 2 (January 2013): 161-168. <http://onlinelibrary.wiley.com/doi/10.1111/1471-0528.12075/pdf>.
- Hannaford R. and J. Tozer. "An Investigation of the Incidence, Degree and Possible Predisposing Factors of Rectus Diastasis in the Immediate Postpartum Period." *The Journal of the National Obstetrical and Gynaecological Special Group of the Australian Physiotherapy Association* 4, no. 2 (1985): 29-34.
- "Health Services, Headquarters Marine Corps." *Marines: The Official Website of the United States Marine Corps*, accessed on February 25, 2015. <http://www.hqmc.marines.mil/Agencies/HealthServices/DirectorofPsychologicalHealth.aspx>.
- Jemmett, Richard S. *Spinal Stabilization: The New Science of Back Pain*. 2nd ed. Canada: Libris Hubris Publishing, 2013.

- Kardel, Kristin Reimers. "Effects of Intense Training during and after Pregnancy in Top-Level Athletes." *Scandinavian Journal of Medicine and Science in Sports* 15, no. 2 (April 2005): 79-86.
- Lee, Diane G. and Linda-Joy Lee. *The Pelvic Girdle: An Integration of Clinical Expertise and Research*. 4th ed. London: Churchill Livingstone, 2011.
- Lee, Diane G., Linda-Joy Lee, and L. McLaughlin. "Stability, Continence and Breathing: The Role of Fascia Following Pregnancy and Delivery." *Journal of Bodywork and Movement Therapies* 12, no. 4 (October 2008): 333-348. <http://ncbi.nlm.gov/pubmed/19083692>.
- Lemos, Andrea, Ariani Impieri de Souza, Ana Laura Carneiro Gomes Ferreira, José Natal Figueiroa, and José Eulálio Cabral-Filho. "Do Perineal Exercises during Pregnancy Prevent the Development of Urinary Incontinence? A Systematic Review." *International Journal of Urology* 15 (2008): 875-880.
- Liaw, Lih-Jiun, Miao-Ju Hsu, Chien-Fen Liao, Mei-Fang Liu, and Ar-Tyan Hsu. "The Relationships Between Inter-recti Distance Measured by Ultrasound Imaging and Abdominal Muscle Function in Postpartum Women: A 6-Month Follow-up Study." *Journal of Orthopaedic & Sports Physical Therapy* 41, no. 6 (June 2011): 435-443. www.jospt.org.
- Marnach, M. L., K. D. Ramin, P. S. Ramsey, S. W. Song, J. J. Stensland, and K. N. An. "Characterization of the Relationship Between Joint Laxity and Maternal Hormones in Pregnancy." *Obstetrics and Gynecology* 101, no. 2 (February 2003): 331-335.
- Mørkved, Siv and Kari Bø. "Effect of Pelvic Floor Muscle Training during Pregnancy and after Childbirth on Prevention and Treatment of Urinary Incontinence: A Systematic Review." *British Journal of Sports Medicine* 48, no. 4 (February 2014): 299-310. <http://bjsm.bmj.com/>.
- Mota, P. G., A. G. Pascoal, Al Carita, and K. Bø. "Prevalence and Risk Factors of Diastasis Recti Abdominis from Late Pregnancy to 6 Months Postpartum, and Relationship with Lumbo-Pelvic Pain." *Manual Therapy* 20, no. 1 (February 2015): 200-205.
- Norris, C. M. "Abdominal Muscle Training in Sport." *British Journal of Sports Medicine* 27, no. 1 (1993): 19-27. <http://bjsm.bmj.com/>.
- "Pregnancy Postpartum Physical Training." *United States Army Public Health Command*. <http://phc.amedd.army.mil/topics/healthyliving/al/pages/armypregnancypostpartumphysicaltrainingprogram.aspx>.
- Rørtveit, Guri and Yngvild S. Hannestad. "Association between Mode of Delivery and Pelvic Floor Dysfunction." *Tidsskrift for den Norske Lægeforening* 134, no. 19 (October 2014): 1848-1852. <http://tidsskriftet.no/pdf/pdf2014/1848-52eng.pdf>.

- Ryan, Marianne. *Baby Bod®: Turn Flab into Fab in 12 Weeks Flat*. Edited by Deborah Grandinetti. Forthcoming.
- Stables, Dot and Jean Rankin. ed. *Physiology in Childbearing: With Anatomy and Related Biosciences*. 3rd ed. New York: Baillière Tindall, 2010.
- “Specialist Certification.” *American Board of Physical Therapy Specialties*, last modified January 26, 2015. <http://www.abpts.org/Certification/>.
- Spitznagle, T. M., F. C. Leong, and L. R. Van Dillen. “Prevalence of Diastasis Recti Abdominis in a Urogynecological Patient Population.” *International Urogynecology Journal and Pelvic Floor Dysfunction* 18, no. 3 (March 2007): 321-328.
- The Pregnancy Centre. “Erica’s Story.” *The Pregnancy Centre*, last modified 2015. <http://www.thepregnancycentre.com.au/post-pregnancy/stories/erica-s-story>.
- Thompson, Judith A. and Peter B. O’Sullivan. “Levator Plate Movement during Voluntary Pelvic Floor Muscle Contraction in Subjects with Incontinence and Prolapse: A Cross-Sectional Study and Review.” *International Urogynecology Journal and Pelvic Floor Dysfunction* 14, no. 2 (June 2003): 84-88.
- Thompson, Judith A., Peter B. O’Sullivan, N. Kathryn Briffa, and Patricia Neumann. “Differences in Muscle Activation Patterns during Pelvic Floor Muscle Contraction and Valsalva Manoeuvre.” *Neurourology and Urodynamics* 25, no. 2 (2006): 148-155.
- Turan, Volkan, Cagdas Colluoglu, Turkyilmaz Esengul, and Korucuoglu Umit. “Prevalence of Diastasis Recti Abdominis in the Population of Young Multiparous Adults in Turkey.” *Ginekologia Polska* 82, no. 11 (November 2011): 817-821.
- U. S. Army Public Health Command. *U. S. Army Pregnancy and Postpartum Physical Training: Implementation Guide*. TG 255A, June 2010. <http://phc.amedd.army.mil/PHC%20Resource%20Library/TG255A0610.pdf>.
- Weina, Stacy Usher. “Effects of Pregnancy on the Army Physical Fitness Test.” *Military Medicine* 171, no. 6 (June 2006): 534-537.
- Wohlfahrt, Deborah, Gwendolen Jull, and Carolyn Richardson. “The Relationship Between the Dynamic and Static Function of Abdominal Muscles.” *Australian Physiotherapy* 39, no. 1 (1993): 9-13.