Solheim E, J Phys Med Rehabil Disabil 2021, 7: 068
DOI: 10.24966/PMRD-8670/100068

HSOA Journal of
Physical Medicine, Rehabilitation and Disabilities

Commentary

A Possible Pathway from Exercise and Movement to Healing Pregnancy-related Diastasis Recti Abdominis (PDRA)

Elin Solheim*

Physiotherapist, Copenhagen, Denmark

Pregnancy-related Diastasis Rectus Abdominis (PDRA) is a prevalent condition. Recently it has been reported that 100 % of women have a PDRA by 35 weeks' gestation, that the separation persists in 40 % when measured at six months postpartum, and that up to 32 % have a PDRA 12 months after postpartum [1,2].

Liaw et al. [3] found that the resting IRD (Inter Recti Distance) was reduced, and that abdominal wall strength improved up to six months postpartum but not to normal values. Sperstad et al. [2], found that 33 % present with PDRA in second trimester already and that the risk of developing DRA increases with heavy resistance training more than 20 h/week. Current evidence has not clarified the risk factors for this condition, but clinically women with PDRA present with a complexity of symptoms from the pelvic girdle, organ support and pelvic floor, such as PGP/ LBP, digestion issues and general discomfort [4]. This is also what I see in my clinic week.

PDRA is a separation of the left and right rectus abdominis and while it occurs in both men and women, pregnancy is the most common preceding event [4]. In biomechanics words this would be correct to say is an unnatural separation since the separation has always been there [5]. In the definition from [6a,b], PDRA is an impairment to the Linea Alba (LA), an aponeurosis or fibrous raphe running along the sheaths of the rectus abdominis muscles. The process involves a widening and thinning of the LA, and hence, DRA is defined as by an increased Inter-Recti muscle Distance (IRD) from normal values. The condition is not limited to the widening and thinning of LA, since the condition involves all the fascia of the abdominal wall according to Brauman et al. [7] and Coldron et al. [8]. To be more accurate one would also need to take into consideration that clinically what might also be present is the widening at the semilunaris (fascia at the lateral border of the R.abd).

***Corresponding author:** Elin Solheim, Physiotherapist, Copenhagen, Denmark, Tel: +45 60641403; E-mail: info@elinsolheim.dk

Citation: Solheim E (2021) A Possible Pathway from Exercise and Movement to Healing Pregnancy-related Diastasis Recti Abdominis (PDRA). J Phys Med Rehabil Disabil 7: 68.

Received: September 29, 2021; **Accepted:** October 08, 2021; **Published:** October 15, 2021

Normal values of IRD differ hugely. According to Beer et al. [9], they found that women between 20 and 45 years of age present with a high variability at all levels, and that widths wider than these were considered abnormal. The most variability was found 3 cm above the umbilicus (13 mm +/- 7), and this is also where Axer et al. found the LA to be thinner [6a,b]. PDRA can involve all regions of the LA, although it is more common in the umbilical and supraumbilical regions [4].

According to Mota et al. [1] and Bo et al. [10], there is no evidence supporting a link between PDRA and PGP (Pelvic Girdle Pain) or LBP (Low Back Pain), measured up to 12 months after delivery. In my clinical work, these women are often presenting with PDRA and this complexity of symptoms years after a delivery and it is therefore my opinion that there is a need to look at the prevalence of this condition in a perspective that reaches further than the 12 months postnatal. In 2019 Benjamin et al [11] showed weak evidence that PDRA may be associated with pelvic organ prolaps and PDRA severity (width) with impaired health-related quality of life, impaired abdominal muscle strength and low back pain severity.

In my physiotherapy clinic I see women who have been living with PDRA for many years, presenting with back- and pelvic pain, incontinence, POP (Pelvic Organ Prolapse) and abdominal muscle weakness. What Diane Lee has made me even more aware of and what I also see clinically is that the wider the IRD (and with increased width comes often increased depth), the tendency is that the more symptoms they present with. They often have a sense of being unprotected and vulnerable in the belly area when handling and interacting with their kids, when clothes add a pressure to the tissue, or having a feeling of discomfort when lying on their side at night or when bending forward. Often what they tell me is that they have been working out trying to strengthen their abdomen specifically, but that they experience a lack of connection to the deep support system, lack of support in the belly area despite muscular contraction, and that the belly keeps doming in their belly midline, sometimes giving a feeling of the belly "falling out" in side laying position, sometimes even more after exercise. An example of what I see is ex. that even the gentle forces generated when lifting both arms over head standing, can create a pyramid shaped Linea Alba doming in the belly midline. This LA doming represents the distortion or laxity in the LA, where functionally there is a lack of tension and support with increased IAP (Intra-Abdominal Pressure).

Long-Term Implications

The implications of long-term lack of support in the belly area are often a mixture of many things and more often than my other clients they also present with digestion issues like gas, belly volume increasing unproportionally to the amount of the intake of food, and constipation or loose stools, or both. As soon as their movement strategies change and there is a more integrated functional support unit around the belly, this is one of the first improvements they experience: More stable digestion system.

It can be tricky to differ their pains in back and pelvic areas from the issue of PDRA when many of my clients first realize they have got a PDRA as many as 5-10 years after their last pregnancy, and not seldom 10-15 years since their first delivery. How am I ever supposed to know what came first, and which complications is added along the way? How can we say, that having PDRA for 15 years does not affect the function and surroundings of the spine and pelvis?

In a biomechanical perspective it is also hypothesized that the intra abdominal pressure, habitual movement patterns and loads of our body and core especially, may have the potential to create forces that deform LA over time, like increased intra abdominal fat, positioning of ribcage or rigid muscles of the core laterally (lack of sliding and elasticity) [5].

Therefore, before concluding that there is no link between these conditions it would be necessary to look at the long-time consequences of LA impairment and thereof affected core function. It would also be fair to say, that evidence on the functional consequences of PDRA is lacking [12]. Regarding these consequences, that there is clinical evidence that everyone with a separation wider than 2 cm should not be considered the same way since they generally tend to present with more symptoms the wider the IRD and depths there is.

Evidence-Based Methods

To this date we still have no evidence-based method for strengthening and healing the connective tissue deformation specifically as seen in PDRA. Nor is there an evidence-based method for functionally reintegrating Linea Alba specifically dealing with core stability and movement. According to Benjamin et al. [13], the evidence available and quality of this evidence shows that non-specific exercise may or may not help to prevent or reduce PDRA during the ante- and postnatal periods. We should be aware though; that most of these studies are looking at reduction of the IRD only, which in my opinion is less important and a late part of the process. As I will discuss later in this article, the ability to generate tension and transfer load across the midline is more important for function. There is, on the other hand, quite a few studies on mechano-stimulation and tissue remodeling in tendon, and clinical perspectives that might shed some light on how this condition can be treated more efficiently. Since 2007 there has been an increasing activity in the research field of connective tissue, more specifically fascia and the fascial system, its plasticity, and its role in movement and movement control.

Even with poor evidence, exercise is one of the most common modalities used by physiotherapists to address PDRA during perinatal period [13]. The PDRA is dealt with in numerous online theories and programs worldwide, despite limited clinical research on the condition. Contradicting recommendations and poor evidence-based knowledge make it a very unsatisfying situation for both the women (and some men) suffering from the condition and finding their way dealing with it, and for the therapists trying to treat it [4].

The Core

PFM (Pelvic Floor Muscles) contribute to both postural and respiratory functions, and it is fair to say; is the "ground floor" of the core [14]. The locally stabilizing function of the core has for some time been linked to other deeper tissues of the core as well, I will call it the Deep Stabilizing System (DSS). The deeper and more locally stabilizing structures involving the Pelvic Floor Muscles (PFM), Tr. Abdominis (Tr.abd.), the diaphragm and transvers spinal system. While R. Abdominis (R.abd.), Oblique Externus (OE) and Oblique Internus (OI) are considered part of the more superficial and globally stabilizing movement-generating structures. Research has shown that the deepest muscles of the abdominal canister (Tr.abd, diaphragm and the PFM), never stop working and are multitasking. Tr. Abd is tonically active, physically responsive to breathing, and has peaks of activity in response to certain movements. Al three muscle groups (Tr.abd, diaphragm and the PFM) are anticipatory to anything that perturbs the trunk in any direction [14-18]. The more superficial abdominal muscles (OS, OI, R.abd) have been noted as more phasic, direction specific muscles [4,19,20].

Current evidence suggests that the muscles and fascia of the lumbopelvic region play a significant role in musculoskeletal function as well as continence and respiration [21]. It is also clear that synergistic function of all trunk muscles is required for loads to be transferred effectively through the lumbopelvic region during multiple tasks of varying loads, predictability, and perceived threat. Optimal strategies for transferring loads will balance control of movement while maintaining optimal joint axes, maintain sufficient intra-abdominal pressure without compromising the organs (preserve continence, prevent prolapse or herniation) and support efficient respiration.

The diaphragm is also anticipatory and increases its tonic activation and phasic response during tasks that perturb the trunk through the extremities [15,16]. The same pattern holds true for the deep muscles of the pelvic floor including the levator ani: They are tonically active, eccentrically lengthen during inhalation, concentrically shorten during expiration, are anticipatory and phasically responsive to increases in Intra-Abdominal Pressuren (IAP) and tasks that perturb the trunk [14,22]. Respiration and especially expiration has been shown to be more connected to the deep pelvic floor muscular layer than the superficial, but both layers are connected to respiration [14,22,23], seen as task-specific differences in respiration-related activation of deep and superficial pelvic floor muscles [22].

There is a synergy between PFM and Tr.abd, and it has been shown that an 10-15 % PFM activation is enough to co-contract the Tr.abd [4,14,17]. This co-activation results in increased intra abdominal pressure and, therefore, increased tension in the thoracolumbar fascia and likely the anterior abdominal fascia and LA. A study from Kim et al. in 2016 [24], also showed that PFM activation seems more efficient in recruiting Tr.abd than an active expiration or pushing the belly button inwards, and that these latter strategies seem to recruit the OE more.

Summary of the Core

The core is functioning through a complex myofascial recruitment pattern as a whole unit, and optimal strategies for transferring loads will balance control of movement and support systems. The Deep Stabilizing System (DSS) plays a crucial role in stability and transfers of loads.

The Fascial System

Before describing the hypothesis of a possible pathway, it´s important to understand the physiology and function of connective tissue, both the loose irregular connective tissue and dense connective tissue called fascia – together forming what is called the fascial system. To understand the functional forces at play in PDRA we especially need to know the aponeurotic or fibrous raphe making the Linea Alba running along the sheaths of the rectus abdominis muscles. All fasciae are connective tissue, but connective tissues are not always fascia since this also covers specialized connective tissues such as blood

and bone. In 2018 the 4th international Fascia Research Conference Nomenclature Committee said that "the fascial system consists of the three-dimensional continuum of soft, collagen containing loose and dense fibrous connective tissues that permeate the body". In 2019 there was an update: "A fascia is a sheath, a sheet, or any other dissectible aggregations of connective tissue that forms beneath the skin to attach, enclose, and separate muscles and other internal organs. The fascial system surrounds, interweaves between, and interpenetrates all organs, muscles, bones, and nerve fibers, endowing the body with a functional structure, and providing an environment that enables all body systems to operate in and integrated manner [25].

The fascial system therefore consists of both more, or less regulated dense connective tissues such as fascia, and loose irregular connective tissue and "padding" tissues, also called Sliding System by Guimberteau [26]. Sliding system is the loose, irregular continuum of fibrillar network that forms fluid filled micro volumes everywhere in the body. It is a highly present continuity of fluid-filled intra-tissular fibrillar network that extends from the surface of the skin to the periosteum, connecting and allowing movement such as sliding and gliding function between adjacent structures [26]. In the body there is no separate layers: "The concept of tissue layers, neatly arranged in separate strata, compartments and sheaths, although useful as a means of teaching and learning anatomy, is ultimately false", Guimberteau states. This means that there is both a fibrous component and the component of the loose, irregular connective tissue where fluids are even more present, mainly proteoglycans and water. Carla Steccos presentation describes this very well: If our target is the fibrous component, we need to stimulate the fibroblasts increasing the fascial tension according to specific directions. If our target is the loose connective tissue, we need to pay attention to temperature; hydration and the movement must be multidirectional [27].

There is reason to think that there is a high degree of sliding involved in the complexity of the core function, since the fascial system plays at bigger role in the myofascial recruitment patterns of the core, not only in LA. But in the perspective of healing PDRA the fibrous component is equally interesting.

The Fibroblast is the primary cell responsive for producing and organizing collagen in connective tissues primarily through tension stimuli [28,29]. Meanwhile the fasciacytes is devoted to creating gliding through the production of Hyaluronan from shearing forces [30]. This mechano transducive process via the fibroblasts´ highly mechano sensitive function is depending on the direction and variation of mechanical stimuli such as tension, shearing forces and compression. Chee Ping NG, Boris Hinz and Melody A. Swartz showed how interstitial fluid flow induces myofibroblast differentiation and collagen alignment [31]. This leads to the recognition, that our connective tissue is constantly object to forces or the lack of it, and therefore highly mechano sensitive whether we are conscious of it or not, whether the tissues are exercised or not. Not only exercise matters. Movement matters, and the positions in-between movements matter.

Linea Alba

The Linea Alba has the function of providing a strong point of attachment and offering resistance to a working connected muscle, essentiel for producing force [5]. In the case of the core, together with the thoracolumbar fascia posteriorly, LA is a central point of attachment for many of the core muscles, and therefore the aponeurosis of Linea Alba has great importance for core function and movement. Linea Alba is a highly organized fibrillar network and is derived from the aponeuroses of the lateral abdominals and the rectus sheaths [4]. Axer et al. [6a,b] found that Linea Alba has a general pattern of fibril orientation antero posterior. In the supraumbilical and infraarcuate region primarily, the intermediate zone consists mainly of transversal fibrils that comes from the aponeurosis of Tr.a, while there is a superficial ventral zone of obliquely orientated fibers from OE and OI, and a thin dorsal zone of obliquely orientated fibers. This supports the understanding that at pull from Tr.abd will create tension in LA, and that this fibrillar arrangement provides greater resistance to lateral forces while still permitting elongation in the craniocaudal dimension [4,6a,b]. This also contradicts earlier suggestions from Grays Anatomy (2008) that Tr.abd. narrows IRD like a corset when it contracts suggesting that it crosses and becomes the poneurosis of another muscle [4]. In other words, it is unlikely that an abdominal muscle contraction can reduce IRD through tension in Linea Alba. But rather that LA tension generated from transversal forces through Tr.abd can create lines of stress. And that this tension prevents the distance from getting bigger, feeds the ongoing mechanotransducive process, and that this resistance over time prevents the diastasis from opening more.

According to Michael Kjaer, collagen fibers respond to loading through tension, and lay down along lines of stress [32]. From the data present today, it is clear that mechanical loading provides one of the strongest stimuli, if not the strongest, towards an adaptation of matrix tissue that becomes stronger and, in an injury recovery situation, heals faster and better than if no loading were present [33].

If collagen synthesis and reorganization is required for repair of PDRA, then loading the tissue is necessary. In other words and for this reason, abdominal binders should not be used carelessly, also supported in Diane Lees clinical guide [4].

According to Carla Stecco, the mechanotransducive process in the fascial system is vulnerable when there is a lack of variation and direction, and the loads are too constant [27]. Not too much and not to little is crucial to enhance load transmission. In swedish there is a word "lagom" for that. The key is to find how much is enough and how often is enough.

Magnusson and Kjaer have also showed that the connective tissue is very vulnerable when not being mechanically loaded [34]. Lack of tension removes the mechanotransducive signaling and context related to remodeling, and the result might be a more chaotic collagen organization, less adapted to loads. 2 weeks of immobilization showed up to 80 % reduction of collagen synthesis [34]. The complete turnover time in tendons is much slower than in muscle tissue, estimated to be 100 % in 2 years/24 months, intramuscular collagen turnover being faster, and that exercise do speed the turnover up to some degree. We don´t know enough, we don´t know everything, and possibly only 5 % of the tissue is mechanically responsive to tissue loading and remodeling after the age of 18. These 5 % might also only be present in the inter fascicular areas, as seen in that of tendons [35,36].

Ceydeli et al. [37] has showed that the abdominal fascia after cecerian only has 59 % scar tissue strength 6 weeks postnatal, yet up to 93 % 6-7 months postnatal. This too points in the direction of a long-term remodeling activity, and of finding meaningful longtime interventions that can stimulate this connective tissue healing in a functionally adaptable context

Smeets et al. [38] also suggests that musculoskeletal tissues such as tendon, bone, cartilage, ligament and menisci may express a greater level of tissue plasticity and protein synthesis rates than generally believed, ex. being greater in anterior cruciate ligament than m. vastus lateralis, and lower in post. Cruciate ligament, where loads are lower.

Kjaer states that humans may stimulate their connective tissue with low levels of intensity, at a time where the tissue would otherwise be too weak to tolerate heavy muscle resistance training [32].

Studies from Wingerden et al., [39], confirmed Axers findings that the viscoelastic property of LA differs in the transversal and the longitudinal plane and that the most stabilizing and least elastic properties is found in the transversal plane in the intermediate part, and that this indeed is connected to the myofascial connection to Tr.abd. muscle. Also, they found that there is a great deal of sliding between this posterior myofascial connection of the rectus sheath and the posterior aspect of the R.abd, while the ventral portion of the R.abd. Muscle and the ventral sheath were well adhered. This study in all points to the direction that the posterior part of the rectus sheath functionally is more connected to Tr.abd and to the intermediate part of LA where the most stabilizing properties are found. They suggest that Tr.abd. Pulls the LA down and out, creating tension.

And that this demands coordinated muscle recruitment especially in relation to Tr.abd , PFM and R.abd. Hodges and Lee also have demonstrated how the distortion of LA increases and the IRD decreases in a curl-up when the Tr. abd. is not recruited sufficiently to tense the LA. Meanwhile the IRD increases and the distortion of the LA decreases when Tr.abd is recruited, creating tension in LA. Since tension is at crucial parameter in collagen synthesis and remodeling, this could be a central mechanism. Wingerden furthermore challenges the typical views on abdominal exercise and strength, by shedding more light on the core function as a pressure-tolerant container. Both muscular and fascial tissues contribute to supporting and creating pressure tolerance, and Wingerden also recommends strengthening the abdominal wall without creating unnecessary compression on the internal organs, since this will lead to an increased IAP and fluid filled organs are not able to compress.

Summary Core, Fascial System and Linea Alba

Based on present knowledge there is fair reason to say that the facial system is plastic, and that the overall structure in LA is a result of the loads, the direction and variation of the loads over time and that if our target is the fibrous component, we need to stimulate the fibroblasts increasing the fascial tension according to specific directions. Tension in LA is primarily generated through contraction of Tr.abd, yet this is an integrated part of the synergies of the core as a unit. Based on present knowledge there is a fair reason to say that recruitment patterns and muscular strategies that predominantly builds on superficial abdominal muscles, although often efficient in presenting with a toned and in an esthetic sense strong abdomen, is not necessarily generating the tension and healing circumstances necessary for increased LA integrity.

Perspectives

There is to this date no evidence-based link between strengthening Tr.abd and healing PDRA. Nor between trying to reduce the IRD and healing PDRA. The Norwegian study 2018 from Gluppe et al. [40], shows very clear that a weekly, postpartum, supervised exercise program, including strength training of the pelvic floor and abdominal muscles, in addition to daily home training of the pelvic floor muscles, did not reduce the prevalence of PDRA. But there are three interesting aspects to this study: First, that the before-and-after results that were measured were IRD and the purpose was to reduce this. Dufour et al. [12] shows in a study that generates 28 expert-based recommendations, that there is a wide agreement that "measurement of the inter-recti distance does not provide sufficient and meaningful clinically relevant data." Furthermore that it is important that language emphasizing neuromuscular physiology rather than structure or gap is used when working with these women. An evolved understanding of restoring the integrity of the LA does not translate into "closing the gap as has been understood up until now." They also do not recommend crunches alone to address the complexity of DRA. They recommend that DRA should be assessed thorough generation of tension in LA with voluntary PFM contraction, assessment of Pelvic floor function, and assessment of LA at rest via palpation to determine integrity via depth and qualitative assessment of LA. This calls for a different approach than the measures used in the study from Gluppe et al. to even measure LA behavior.

Secondly, the study from Gluppe et al. had an intervention that lasted for 4 months only, from 6 weeks postpartum. We know from Coldron et al. [8], that a PDRA that does not heal spontaneously within the first 6-8 weeks needs a more specific intervention. But we also know that turnover is slow, and if the collagen synthesis of LA is the aim of the intervention, 4 months is most likely not enough time. Thirdly, there are no cues as to how the women integrated synergies of the core as a unit in motor control and myofascial recruitment patterns in their exercise classes or in their pelvic floor muscle training at home. We simply do not know, or they did not use such muscle recruitment cues to add PFM contractions functionally in their abdominal strength training. The focus of the exercise protocol was to strengthen the PFM, but the program also contained strengthening exercises for the abdominal, back, arm, and thigh muscles, stretching, and relaxation. The pelvic floor exercises took basis in isolated pelvic floor contractions in different positions (maximum, prolonged and fast maximum). The exercise classes focused on abdominal strength training. All exercises, except the PFM exercises, were performed to music. The weekly exercise class included different abdominal exercises, like: Draw-in on all fours or prone, half-plank, side-plank and oblique sit-up, straight sit-up. All exercises are described without any cues for muscle recruitment patterns or synergies. Instead, it is described, that the abdominal exercises were a natural choice when aiming to close the DRA, choosing abdominal exercises that have always been a part of this comprehensive exercise program. Also they were aiming for isolated PFM contractions providing a training effect of Tr.Abd.

From my clinical point of view, most of the abdominal exercises used in this study, are with intensities and complexities that women with DRA only will be able to perform safely much later in the process and only when a functional use of the Deep Stabilizing System (DSS) already is established. Most of the women I see in my clinic, would need to exercise with loads much less for the loads to not compromise LA integrity with increasing IAP, and to respect the degree of motor control.

To me what Gluppe et al. most importantly proves, is that it does matter how you engage your Tr.abd and that there are more complex recruitment patterns at stake than isolated strengthening the abdominal muscles and the pelvic floor. And finally, if you want to heal

PDRA through increased LA integrity and strength of LA, that the tissue needs tension. And that this takes focused attention and movement quality, time, and patience.

Conclusion Hypothesis

The conclusion could be that there is a biomechanical connection between the collagen remodeling, architecture, integrity and function of Linea Alba. And that this again is connected to the direction of tension given from Tr.abd. especially and not trough abdominal muscular tension reducing the gap or IRD. But to explore this further, that we need to consider the core as a whole-which means that myofascial synergies in the Deep Stabilizing System (DSS) between especially PFM, Tr.abd and the Diaphragm is crucial. And that focused attention on movement qualities, rather than the established focus on intensity, muscular tone, rigidity, and higher loads in strength training - can nurture this process more efficiently. And of course, integrating the more superficial, movement-specific and supporting functions of the core too.

The hypothesis is that a possible pathway from exercise and movement to healing PDRA could be found through movement- and recruitment strategies that generates- or potentially generates tension in LA and establishes strategies for this tension to nurture collagen remodeling and re-establishing the core function as at pressure-tolerant container. And that in time, as this strategy is being used regularly both in exercise and movements of daily living, it has the potential to stimulate the direction specific collagen synthesis in LA, and the myofascial recruitment patterns that over time will accumulate further healing in the process, movement by movement. “It is the power of a thousand steps”, Robert Schleip said on the Fourth International Fascia Research Congress in Washington 2015. This is especially true for women with IRD that are especially wide, since they in my clinical experience will have to work for a longer time, 1-2 years often, before they can fully tense the LA and the doming will stop. There is clinical evidence that this calls for a subgroup of severity of this condition, to accommodate the intervention and realistically meet the expectations in each group.

The perspective in this hypothesis is that when we wish to heal and strengthen PDRA, maybe we can come quite far by acknowledging the tension-generating forces, lines of stress and last but not the least - time. There are no quick fixes, but there are especially good reasons to keep moving with PDRA.

References

1. Mota PGF, Poscoal A, Carita AD, Kari B (2015) Prevalence and risk factors of diastasis recti abdominis from late pregnancy to 6 months postpartum, and relationship with lumbo-pelvic pain. Man Ther. 20: 200-205.
2. Sperstad JB, Tennfjord MK, Hilde G, Ellström-Engh EM, kari B (2016) Diastasis recti abdominis during pregnancy and 12 months after childbirth: Prevalence, risk factors and report of lumbopelvic pain. Br J Sports Med. 50: 1092-1096.
3. Liaw LJ, Hsu MJ, Liao CF, Liu MF, Hsu AT (2011) The relationships between inter-recti distance measured by ultrasound imaging and abdominal muscle function in postpartum women: A 6-month follow-up study. J Orthop Sports Phys Ther 4: 435-443.
4. Lee D (2017) Diastasis Recti Abdominis-A clinical guide for those who are split down the middle. Learn with Diane Lee, Canada.
5. Bowman K (2016) Diastasis Recti: The whole-body solution to abdominal weakness and Separation. Propriometrics Press, USA.
6 a. Axer H, Keyserlingk DG, Prescher A (2001) Collagen fibers in linea alba and retus sheaths. I. General scheme and morphological aspects. Journal of Surgical Research 96: 127-134.
6 b. Axer H, Keyserlingk DG, Prescher A (2001) Collagen fibers in linea alba and retus sheaths II. J Surg Res 96: 239-245
7. Hodges PW, Cresswell AG, Thorstensson A (2001) Perturbed upper limb movements cause short-latency postural responses in trunk muscles. Experimental Brain Research 138: 243-250.
8. Brauman D (2008)Diastasis recti: Clinical anatomy. Plast Reconstr Surg 122: 1564-1569.
9. Beer GM, Schuster A, Seifert B, Manestar M, Mihic-Probst D, et al. (2009) The normal width of the linea alba in nulliparous women. Clin Anat 22: 706-711.
10. Kari B, Tennfjord MK, Sperstadet JB, Hilde G, Engh ME (2016) Pelvic floor muscle function, pelvic floor dysfunction and diastasis recti abdominis: Prospective chohort study. Neurourol Urodyn 36: 716-721.
11. Benjamin DR, Frawley HC, Shields N, Alexander TM, Taylor NF (2018) Relationship between diastasis of the rectus abdominis muscle (DRAM) and musculoskeletal dysfunctions, pain and quality of life: a systematic review. Physiotherapy 105: 24-34.
12. Smith MD, Coppieters MW, Hodges PW (2007) Postural response of the pelvic floor and abdominal muscles in women with and without incontinence. Neurology and Urodynamics 26: 377-385.
13. Benjamin DR, Van de Water ATM, Peiris CL (2014) Effects of exercise on diastasis of the rectus abdominis muscle in the antenatal and postnatal periods: A systematic review Physiotherapy 100: 1-8.
14. Hodges PW, Sapsford R, Pengel LHM (2007) Postural and respiratory functions of the pelvic floor muscles Neurourol Urodyn 26: 362-71.
15. Hodges PW, Gandevia SC (2000) Changes in intra-abdominal pressure during postural and respiratory activation of the human diaphragm. Journal of Applied Physiology 89: 967-976.
16. Hodges PW, Ganedevia SC (2000) Activation of the human diaphragm during a repetitive postural task. Journal of Physiology 522: 165-175.
17. Hodges P, Holm AK, Holm S, Ekstrom L, Cresswell A, et al. (2003) Intervertebral stiffness of the spine is increased by evoked contraction of transversus abdominis and the diaphragm: In vivo porcine studies. Spine Phila Pa 1: 2594-2598.
18. Dufour SP, Bernard S, Murray-Davis B, Graham N (2019) Establishing expert-based recommendations for the conservative management of pregnancy-related diastasis recuts abdominis: A delphi consensus study. Journal of Women’s Health Physical Therapy 43: 1
19. Coldron Y, Stokes MJ, Newham DJ, Cook K (2008) Postpartum characteristics of rectus abdominis on ultrasound imaging Man Ther 13: 112-121.
20. Gluppe SL, Hilde G, Tennfjord Mk, Engh ME, Kari B (2018) Effect of a postpartum training program on the prevalence of DRA in postpartum primiparous women: A randomized cotrolled trial. Phys Ther 98: 260-268.
21. Lee DG, Lee LJ, Mc Laughlin L (2008) Stability, continence and breathing: The role of fascia following pregnancy and delivery J Bodyw Mov Ther 12: 333-348.
22. Aljuraifani R, Stafford RE, Leanne MH, Hoorn W, Hodges P (1985) Task-specific differences in respiration-related activation of deep and superficial pelvic floor muscles J Appl Physiol 126: 1343-135.
23. Park H, Han D (2015) The effect of the correlation between the contraction of the pelvic floor muscles and diaphragmatic motion during breathing J Phys Ther Sci 27: 2113-2115.
24. Kim JS, Yang-Hyun K, Eun-Na k, Chae-Rin K, Dong-Kwon S (2016) Which exercise is the most effective to contract the core muscles: A bdominal growing-in maneuver, maximal expiration or Kegel exercise? J Korean Soc Phys Med 11: 83-91.

25. Shleip R, Hedley G, Yucesoy CA (2019) Fascial nomenclature: Update on related concsensus process Clin Anat 32: 929-933.

26. Guimbertaeu JC (2015) Architecture of human living fascia - the extracellular matrix and cells revealed through endoscopy. Handspring Publishing, Scotland, UK.

27. Connect (2021) Connective tissues in sports medicine. Connect, Munich, Germany.

28. Lund T, Langberg H (2007) Fibroblasten hersker lokalt, men tænker global. Fysioterapeuten 9: 4-8.

29. Lund T, Langberg H (2006) Mekanisk påvirkning af cellen. Fysioterapeuten 22: 4-8.

30. Stecco C, Fede C, Macchi V, Porzionato A, Petrelli L, et al. (2018) The fasciacytes: A new cell devoted to fascial gliding regulation, Clin Anat 31: 667-676.

31. Chee Ng, Boris H, Melody AS (2005) Interstitial fluid flow induces myofibroblast differentiation and collagen alignment in vitro. 15: 4731-4739.

32. Kjaer M (2015) Stress loading and matrix remodeling in tendon and skeletal muscle: Cellular mechano-stimulation and tissue remodeling. Fascia in sport and movement, Handspring Publishers, UK.

33. Kjaer M, Jorgensen NR, Heinemeier K, Magnusson SP (2015) Ecercise and Regulation of Bone and Collagen Tissue Biology. Prog Mol Biol Transcl Sci 135: 259-291.

34. Spiesz EM, Thorpe CT, Chaudhry S, Riley GP, Birch HL, et al. (2015) Tendon extracellular matrix damage, degradation, and inflammation in response to in vitro overload exercise J Orthop Res 33: 889-897.

35. Choi H, Simpson D, Wang D, Prescott M, Pitsillides AA, et al. (2020) Heterogeneity of proteome dynamics between connective tissue phases of adult tendon. Elife 12: e55262.

36. Kjaer M, Magnusson P (2018) The impact of loading, unloading, ageing and injury on the human tendon. J. Physiol 597: 1283-1298.

37. Ceydeli A, Rucinski J, Wise L (2005) Finding the best abdominal closure: An evidence-based review of the literature. Curr Surg 62: 220-225.

38. Smeets JSJ, Horstman AMH, Vles GF, Emans PJ, Goessens JPB, et al. (2020) Protein synthesis rates of muscle, tendon, ligament, cartilage, and bone tissue in vivo humans. PLoS One 14 : e0224745.

39. Wingerden JP, Ronchetti I, Sneiders D, Lange JF, Kleinrensink GJ (2020) Anterior and posterior rectus abdominis sheath stiffness in relation to diastasis recti: Abdominal wall training or not? J Body work Mov Ther. 24: 147-153.

40. Hodges PW, Richardson CA (1997) Contraction of the abdominal muscles associated with movement of the lover limb. Physical Therapy 77: 132-42.

HERALD

Advances In Industrial Biotechnology | ISSN: 2639-5665

Advances In Microbiology Research | ISSN: 2689-694X

Archives Of Surgery And Surgical Education | ISSN: 2689-3126

Archives Of Urology

Archives Of Zoological Studies | ISSN: 2640-7779

Current Trends Medical And Biological Engineering

International Journal Of Case Reports And Therapeutic Studies | ISSN: 2689-310X

Journal Of Addiction & Addictive Disorders | ISSN: 2578-7276

Journal Of Agronomy & Agricultural Science | ISSN: 2689-8292

Journal Of AIDS Clinical Research & STDs | ISSN: 2572-7370

Journal Of Alcoholism Drug Abuse & Substance Dependence | ISSN: 2572-9594

Journal Of Allergy Disorders & Therapy | ISSN: 2470-749X

Journal Of Alternative Complementary & Integrative Medicine | ISSN: 2470-7562

Journal Of Alzheimers & Neurodegenerative Diseases | ISSN: 2572-9608

Journal Of Anesthesia & Clinical Care | ISSN: 2378-8879

Journal Of Angiology & Vascular Surgery | ISSN: 2572-7397

Journal Of Animal Research & Veterinary Science | ISSN: 2639-3751

Journal Of Aquaculture & Fisheries | ISSN: 2576-5523

Journal Of Atmospheric & Earth Sciences | ISSN: 2689-8780

Journal Of Biotech Research & Biochemistry

Journal Of Brain & Neuroscience Research

Journal Of Cancer Biology & Treatment | ISSN: 2470-7546

Journal Of Cardiology Study & Research | ISSN: 2640-768X

Journal Of Cell Biology & Cell Metabolism | ISSN: 2381-1943

Journal Of Clinical Dermatology & Therapy | ISSN: 2378-8771

Journal Of Clinical Immunology & Immunotherapy | ISSN: 2378-8844

Journal Of Clinical Studies & Medical Case Reports | ISSN: 2378-8801

Journal Of Community Medicine & Public Health Care | ISSN: 2381-1978

Journal Of Cytology & Tissue Biology | ISSN: 2378-9107

Journal Of Dairy Research & Technology | ISSN: 2688-9315

Journal Of Dentistry Oral Health & Cosmesis | ISSN: 2473-6783

Journal Of Diabetes & Metabolic Disorders | ISSN: 2381-201X

Journal Of Emergency Medicine Trauma & Surgical Care | ISSN: 2378-8798

Journal Of Environmental Science Current Research | ISSN: 2643-5020

Journal Of Food Science & Nutrition | ISSN: 2470-1076

Journal Of Forensic Legal & Investigative Sciences | ISSN: 2473-733X

Journal Of Gastroenterology & Hepatology Research | ISSN: 2574-2566

Journal Of Genetics & Genomic Sciences | ISSN: 2574-2485

Journal Of Gerontology & Geriatric Medicine | ISSN: 2381-8662

Journal Of Hematology Blood Transfusion & Disorders | ISSN: 2572-2999

Journal Of Hospice & Palliative Medical Care

Journal Of Human Endocrinology | ISSN: 2572-9640

Journal Of Infectious & Non Infectious Diseases | ISSN: 2381-8654

Journal Of Internal Medicine & Primary Healthcare | ISSN: 2574-2493

Journal Of Light & Laser Current Trends

Journal Of Medicine Study & Research | ISSN: 2639-5657

Journal Of Modern Chemical Sciences

Journal Of Nanotechnology Nanomedicine & Nanobiotechnology | ISSN: 2381-2044

Journal Of Neonatology & Clinical Pediatrics | ISSN: 2378-878X

Journal Of Nephrology & Renal Therapy | ISSN: 2473-7313

Journal Of Non Invasive Vascular Investigation | ISSN: 2572-7400

Journal Of Nuclear Medicine Radiology & Radiation Therapy | ISSN: 2572-7419

Journal Of Obesity & Weight Loss | ISSN: 2473-7372

Journal Of Ophthalmology & Clinical Research | ISSN: 2378-8887

Journal Of Orthopedic Research & Physiotherapy | ISSN: 2381-2052

Journal Of Otolaryngology Head & Neck Surgery | ISSN: 2573-010X

Journal Of Pathology Clinical & Medical Research

Journal Of Pharmacology Pharmaceutics & Pharmacovigilance | ISSN: 2639-5649

Journal Of Physical Medicine Rehabilitation & Disabilities | ISSN: 2381-8670

Journal Of Plant Science Current Research | ISSN: 2639-3743

Journal Of Practical & Professional Nursing | ISSN: 2639-5681

Journal Of Protein Research & Bioinformatics

Journal Of Psychiatry Depression & Anxiety | ISSN: 2573-0150

Journal Of Pulmonary Medicine & Respiratory Research | ISSN: 2573-0177

Journal Of Reproductive Medicine Gynaecology & Obstetrics | ISSN: 2574-2574

Journal Of Stem Cells Research Development & Therapy | ISSN: 2381-2060

Journal Of Surgery Current Trends & Innovations | ISSN: 2578-7284

Journal Of Toxicology Current Research | ISSN: 2639-3735

Journal Of Translational Science And Research

Journal Of Vaccines Research & Vaccination | ISSN: 2573-0193

Journal Of Virology & Antivirals

Sports Medicine And Injury Care Journal | ISSN: 2689-8829

Trends In Anatomy & Physiology | ISSN: 2640-7752