Women. Health. Bull. 2024; 11(4)
Published online 2024 October.

Original Article

Effectiveness of Dynamic and Static Plank Exercise on Inter-Recti Distance in Postpartum Women

Mahsa Khademi[1], MSc; Raheleh Ghaffari[1], PhD; Komeil Dashti Rostami[2*], PhD

[1]Faculty of Sport Science, Shomal University, Amol, Iran
[2]Department of Motor Behavior and Biomechanics, Faculty of sports sciences, University of Mazandaran, Babolsar, Iran

Corresponding author:* Komeil Dashti Rostami, PhD; Department of Motor Behavior and Biomechanics, Faculty of Sports Sciences, University of Mazandaran, Postal code: 47419-73446, Babolsar, Iran. **Tel: +98 11 35302201; **Email:** k.dashti@umz.ac.ir

Received: May 12, 2024; **Revised:** June 16, 2024; **Accepted:** June 26, 2024

Abstract

Background: Diastasis of Rectus Abdominis (DRA) is a frequent problem that affects women during pregnancy and postpartum. The study aimed to investigate the effectiveness of static and dynamic plank exercise on Inter-Recti Distance (IRD) in postpartum women.
Methods: This semi-experimental study included 30 postpartum women with DRA who were randomly divided into static plank (N=10), dynamic plank (N=10) and control group (n=10). Exercise groups implemented the plank exercise three times weekly for six weeks in Sari, Iran from April to May 2023. Ultrasound imaging was recorded to measure IRD in three locations, center of umbilicus (reference point), three cm above and three cm below umbilicus. The analysis of covariance (ANCOVA) was used to compare the effect of static and dynamic plank exercise on IRD.
Results: IRD significantly decreased in static (29 mm vs 27/4 mm, P=0.001) and dynamic (30.1 mm vs 27 mm, P=0.001) plank groups after exercise. IRD did not significantly differ between static and dynamic groups at post-test (P=0.420). However, the percentage of the change was greater in dynamic (10.33%) compared with the static (5.51%) group. A significant difference was observed between the dynamic and control groups (P=0.001).
Conclusion: The findings revealed that both types of plank exercise could cause narrowing of IRD in postpartum women. However, based on the percentage of change, incorporating additional movements such as abduction and rotation in dynamic plank, which could produce more muscle activity, yielded greater reduction in IRD compared with static plank.

Keywords: Rectus abdominus, Core stability, Muscle weakness, Linea alba

How to Cite: Khademi M, Ghaffari R, Dashti Rostami K. Effectiveness of Dynamic and Static Plank Exercise on Inter-Recti Distance in Postpartum Women. Women. Health. Bull. 2024;11(4):222-230. doi: 10.30476/whb.2024.102632.1293.

1. Introduction

Diastasis of the Rectus Abdominal Muscles (DRA) is a usual complication during and after pregnancy which result in the rectus abdominis dissociation in the line of the linea alba (1). The incidence of Diastasis of the Rectus Abdominis Muscle (DRAM) is about 66% in women who are in their third trimester of pregnancy (2); however, some researchers reported 100% of pregnant women experiences DRA (3). It has been demonstrated that this situation usually occurs in the second trimester of pregnancy, and will be more obvious in the third trimester and proceed after delivery (2). DRAM is usually associated with weakness of abdominal muscles, pelvic floor malfunction, low back pain, pelvic pain, and urinary disorders (4, 5). Possible risk factors for DRA are increased weight, high levels of progesterone, relaxin, estrogen and mechanical pressures on abdominal wall by growing fetus (6).

For diagnosing and assessing the existence of DRA, Inter-Rectus Distance (IRD) is measured (7). There are some methods for measuring IRD including ultrasound, caliper and palpation (8), among which ultrasound has the best reliability (9). There is no consensus about the limit to diagnosis DRA (10); however, the values more than 28 mm is considered clinically significant and normal values for IRD six months after delivery are between 17 mm to 28 mm (3).

There are various active and passive interventions for managing and reducing DRA. These interventions include functional activities, transversus abdominis and pelvic floor muscle activation, manual therapy and multifidus training (11). If the conservative treatment is not effective and great aesthetic and/or functional discomfort or hernia exist (12), surgery is usually considered (13).

Exercise therapy is the most common conservative intervention for addressing DRA in postpartum women (14-16). Abdominal exercise is often suggested as a main intervention for women with DRA (17). The most common exercises are those targeting transversus abdominis and pelvic floor muscles (18).

Among abdominal exercise, plank is a form of the isometric exercise that could strengthen core muscles (19). Plank exercise is a whole-body exercise which could consume high calories and strengthen muscles in a short duration (20). Previous studies demonstrated that plank exercise is useful in IRD (14), enhancing strength and endurance (21), decreasing low back pain (22) and preventing falls (23). There are some variations of plank exercise including static, dynamic, stable surface, unstable surface and with devices which could impact abdominal muscles in a different way (24). In static exercise, the body held in static position with or without external resistance (sub-maximal muscle action) (25). In dynamic exercise, muscles produce force concentrically or eccentrically over time (26). It seems that dynamic exercise is more challenging for core musculature than just muscle static action as in static exercise (27). Previous studies has investigated the effects of dynamic and static core stabilization training on performance in field tests (27), dynamic balance, spinal stability and hip mobility (25); however, there is rare information about the effectiveness of dynamic and static plank exercise on IRD in postpartum women. Therefore, the present study aimed to examine the effectiveness of dynamic and static plank exercise on IRD in postpartum women. The first hypothesis in this study was that both plank exercise types (static and dynamic) would reduce IRD in women. The second hypothesis was that dynamic plank would be more effective in decreasing IRD in postpartum women.

2. Methods

2.1. Study Design

The study design was a semi-experimental including 3 groups of participants. Group A (exercise group) performed static plank exercise, group B (exercise group) performed dynamic plank exercise and group C (control group) did not receive any intervention.

2.2. Participants

We used convenient sampling method to recruit sixty postpartum women at six months to two years after childbirth from private sport clubs in Sari, Iran. Thirty women were excluded or declined to participate. A total of 30 women participated in the present study. G-power software was used to calculate sample size, given the mean and standard deviation of IRD for control=29.69±1.61, static plank=27.81±1.74 and dynamic plank group=27.62±2.13 (28), which revealed that 30 participants is needed to achieve a statistical power of 0.80. We assigned each participant a number from 1 to 30 and then, by a random generator number, placed each participant randomly in static plank (n=10), dynamic plank (n=10) and control group (n=10) (Figure 1). The inclusion criteria were 1) 20 to 40 years of age; 2) IRD>2.5 cm; 3) vaginal delivery; 4) body mass index not exceeded 30 kg/m^2 and 5) six months to 2 years after child birth. The exclusion criteria were 1) cardiovascular, hypertension, diabetes mellitus diseases 2) a history of pelvic and abdomen surgery 3) neurological diseases and 4) more than 2 pregnancies. The study participants performed exercises in a private club in Sari, Iran from April to May 2023.

The protocol of the study was approved by the Ethics Committee of Shahrood University of Technology, Shahrood, Iran. The study participants signed an informed consent.

2.3. Intervention

The dynamic plank group consisting of 10 participants performed four exercises including rotational plank, cross plank, spiderman plank and jack plank. The static plank group consisting of 10 participants performed four exercises including forearm plank, palm plank, TRX plank and buso ball plank (Figure 2). The exercise intervention group performed for 6 weeks, three times a week, and each exercise session was 30 minutes. The level of difficulty of exercise increased based on sets, repetitions and times (Table 1). The exercise program for experimental groups was performed in physiotherapy clinic with direct supervision of two physical therapists. The control group received no intervention.

2.4. Measurement of IRD

IRD was measured by Ultrasound (Supersonic aixplorer mach20, France). Ultrasound imaging (USI) is the gold standard and the most valid method for non-invasive IRD assessment (9). The images

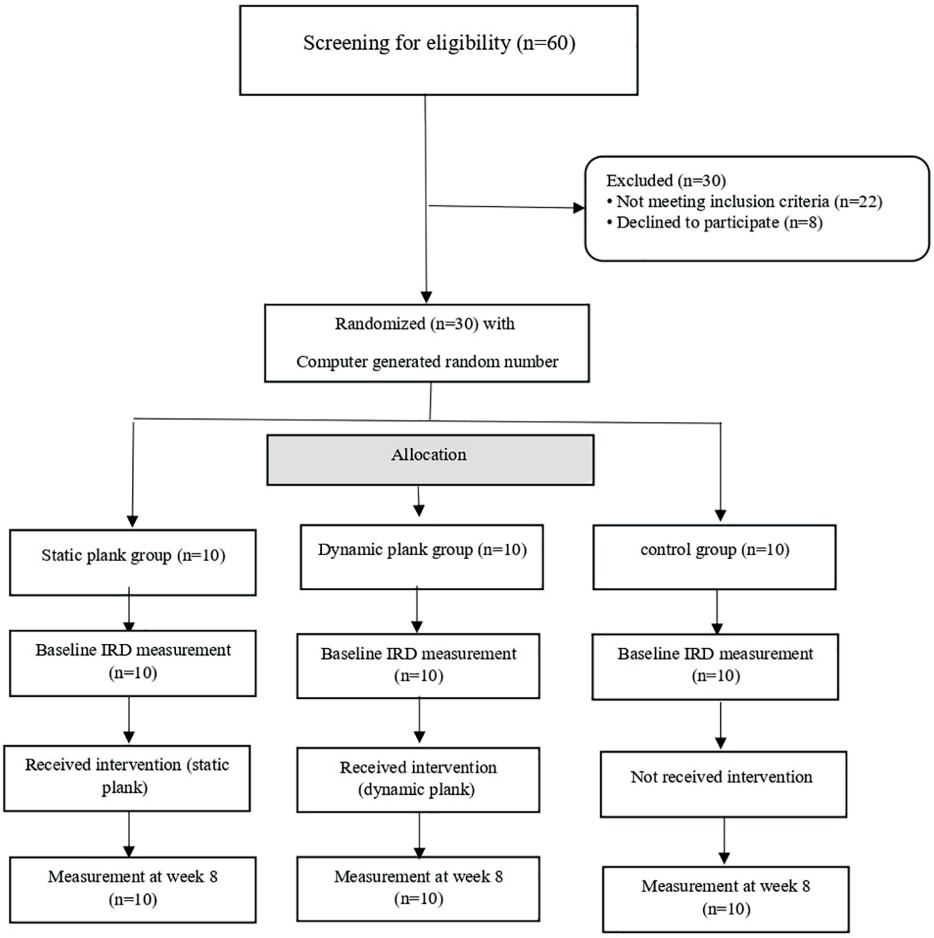

Figure 1: The figure shows the diagram of the study.

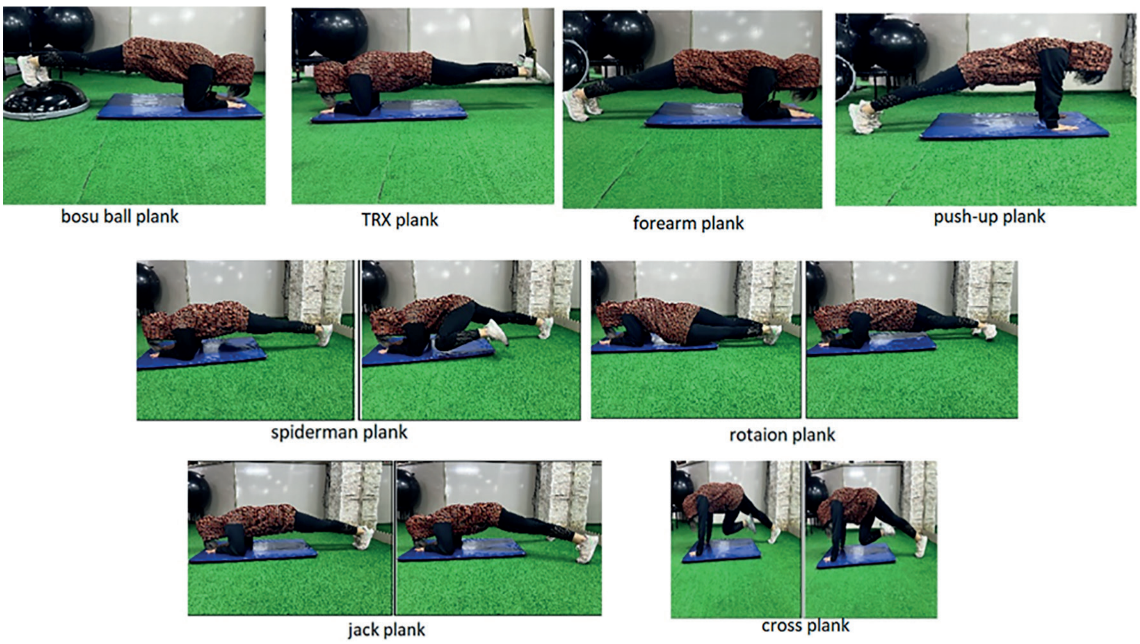

Figure 2: The figure shows the illustration of static and dynamic plank exercises.

were taken with participants in the lying back position with knees flexed to 90°, feet placed on the table and arms beside the body. Measurements was performed in three locations, center of umbilicus (as reference point), 3 cm over and 3 cm under umbilicus. The thickness of rectus abdominus was assessed by drawing a horizontal line in lateral direction (7) (Figure 3). The mean value of IRD was

Table 1: Exercise program for static and dynamic groups

Exercise group	Static plank Set * time(sec)	Dynamic plank Set * reps
Week 1	2 * 10	2 * 6
Week 2	2 * 15	2 * 8
Week 3	3 * 20	3 * 10
Week 4	3 * 30	3 * 12
Week 5	4 * 45	4 * 15
Week 6	4 * 60	4 * 20

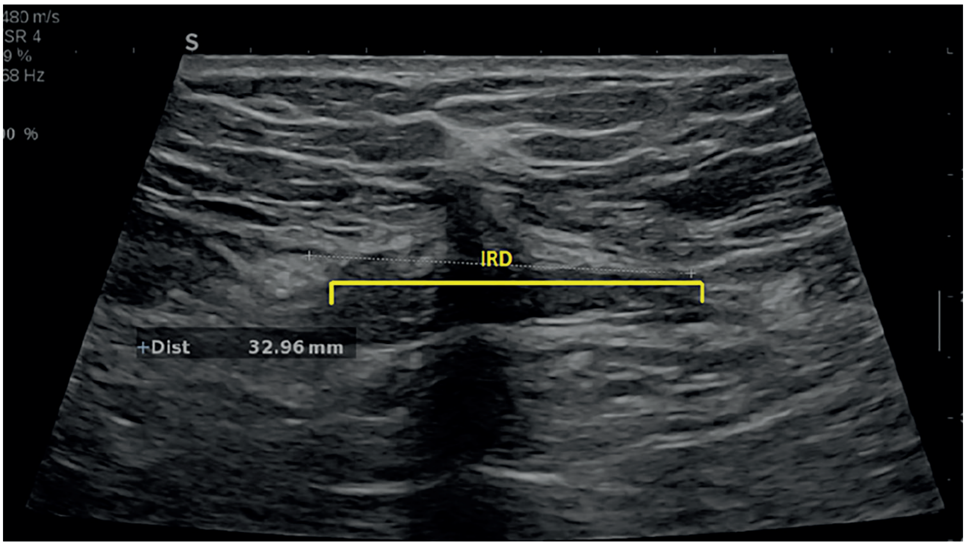

Figure 3: The figure shows an example of image to measure of IRD. IRD: Inter-Recti Distance

Table 2: Demographic features of the subjects

	Static group	Dynamic group	Control group	P value
Age (years)	32.40±2.95	34.30±3.37	35.70±4.55	0.152
Weight (kg)	73.40±6.95	71.57±5.54	74.72±7.84	0.612
Height (cm)	164.40±5.07	164.80±5.80	163.30±6.42	0.588
BMI (kg/m^2)	25.57±2.19	26.87±5.60	27.15±5.52	0.467
Birth weight (kg)	3.15±0.16	3.02±0.11	3.09±0.14	0.562

BMI: Body Mass Index

calculated from five images captured.

2.5. Statistical Analysis

Normality of the variables was examined by the Shapiro-Wilk test. The differences in IRD between the three groups were compared with ANCOVA and then post hoc Bonferroni was used to compare pairwise means. Within group differences (pre to post) were analyzed with paired t-test. Cohen d effect size (ESs) was calculated to measure group differences in dependent variable. ESs Interpretation was based on the recommendations reported by Cohen (29) to be weak (<0.5), moderate (0.5 to 0.79), and strong (>0.8). Statistical analysis was implemented by SPSS software version 22.0 (SPSS Inc., Chicago, IL, USA).

3. Results

Thirty postpartum women with mean age=34.13±3.87, mean weight=73.23±6.72, mean height=164.16±5.46 and mean BMI=26.53±4.36 participated in the present study. The demographic features of the study participants in the three groups are shown in Table 2.

There were significant differences in IRD from pre- to post-test for the two exercise groups (static, P=0.001 and dynamic, P=0.001). Specifically, IRD significantly decreased in the two exercise groups after plank exercise (Table 3). The examination of effect sizes indicates small and moderate effect for static and dynamic groups, respectively.

Table 3: Paired t-test for difference in IRD within groups					
Group	**Pre-test**	**Post-test**	**P**	**%change**	**ES**
	Mean (mm) ±SD	**Mean(mm) ±SD**			
Control	30.00±5.08	29.50±4.38	0.213	1.60	0.10
Static plank	29.00±5.62	27.40±5.70	0.001*	5.51	0.28
Dynamic plank	30.10±6.08	27.00±5.19	0.001*	10.33	0.55

*Indicates significant deference from pre to post in IRD. IRD: Inter-Rectus Distance; SD; Standard Deviation; ES; Effect size; mm: Millimeter

Table 4: Pairwise comparison of IRD in three groups with Bonferroni post hoc test			
Pairwise comparisons	**Mean difference**	**P**	**ES**
Control-static	2.1	0.087	0.41
Control-dynamic	2.5	0.001*	0.52
Dynamic-isometric	0.40	0.42	0.07

*Indicates significant difference between dynamic and control group at posttest. IRD: Inter-rectus distance; ES: Effect size

The results of ANCOVA indicated that with considering pre-test as covariate, there was significant difference in IRD between the groups. In Bonferroni post hoc analysis, a significant difference was seen between the dynamic and control groups (P=0.001) at post-test. However, significant difference was not observed in IRD between the static and control groups (P=0.087), and static and dynamic groups (P=0.420) at post-test (Table 4).

4. Discussion

The present study investigated the effectiveness of two distinct plank exercise (static and dynamic) over a period of six weeks at six months to two years postpartum in 30 women diagnosed with DRA.

According to our results, IRD significantly decreased in both static and dynamic groups after six weeks intervention. This finding supports our first hypothesis. Previous studies have demonstrated the effect of core muscle exercise (4, 30), plank exercise (14), abdominal crunch and draw-in exercise, (31) on IRD. The adaptations in the abdominal muscles induced using plank exercise can explain reduction in IRD. It has been demonstrated that abdominal exercises could activate further motor units inside muscle fibers, use fast twitch (FT) and slow twitch (ST) fibers and greater amount of FT fibers boosts muscle force. Furthermore, core exercise could enhance muscle power and endurance by influencing the metabolic demand of the targeted muscle force (32). It has been shown that performing plank exercise in challenging condition improve abdominal muscle activation (33). In our study, the static group performed two plank exercises on the Bosu ball and TRX which could increase the demand on abdominal muscles.

The second hypothesis of the study was that dynamic plank exercise would be better than static plank for decreasing IRD; however, our findings did not support this hypothesis. IRD did not differ significantly between the dynamic and static plank groups. It should be noted that the percentage of change and effect size for the dynamic group was more than the static group (10.33% vs 5.51%, 0.55 vs 0.28, respectively). The index of effect size based on Cohen d shows a moderate and small effect for the dynamic and static groups in decreasing IRD respectively; thus, if we consider practical significance compared with statistical significance, it seems that dynamic plank was more effective than static plank. It has been demonstrated that additional limb movement and incorporating perturbation to trunk and lower extremities improve abdominal muscles activation during plank exercise (34). Kim and colleagues showed that adding bilateral and unilateral hip adduction during plank would significantly increase all abdominal muscle activity in contrast with usual plank exercise (35). Yoon and co-workers stated that incorporating hip adduction and abduction during bridge exercise, in comparison with the bridge exercise alone, induced significantly more activity in the rectus abdominis, internal oblique and multifidus muscles (36). One explanation is that adding limb movement outer base of support would destabilize the trunk and could increase contralateral abdominal muscle activation to keep neutral condition of trunk (37). In our study, the dynamic group added hip flexion, abduction and rotation movements during plank exercise which could result in greater activity in abdominal muscles and more decrease in IRD compared with static plank exercise.

4.1. Limitations

There were some limitations in our study. It is difficult to generalize the results to a larger population because of our small sample size. The exercise program was performed in short duration and future studies could examine the effect of long-term exercise program (more than 10 weeks) on IRD. The absence of pre-pregnancy measurement of IRD influences the interpretation of the results. Psychological factors, such as self-confidence, may influence the ability of women to perform exercise.

5. Conclusion

According to our results, it seems that both types of plank exercise (static and dynamic) reduce IRD in postpartum women. No significant difference was seen between the effectiveness of static and dynamic plank exercise in decreasing IRD. However, based on the percentage of change and effect size index, it seems that dynamic plank with incorporating some additional movements such as hip adduction, abduction and rotation could result in greater reduction in IRD compared with static plank exercise.

Acknowledgment

This article was extracted from the thesis of Ms. Mahsa Khademi in Department of Exercise Physiology and Corrective Exercise, Faculty of Sport Sciences, Shomal University, Amol, Iran. We appreciate all the participants who helped us in the implementation of project.

Authors' Contribution

Mahsa Khademi: Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work, drafting the work. Raheleh Ghaffari: Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work, drafting the work. Komeil Dashti Rostami: Substantial contributions to the conception and design of the work; the acquisition, analysis, and interpretation of data for the work, drafting the work, contributions to the conceptualization, supervision, validation, visualization and contributed to statistical analysis of the study, drafting the work and reviewing it critically for important intellectual content. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work, such that the questions related to the accuracy or integrity of any part of the work.

Ethical Approval

The study was approved by the Research Ethics Committee of the Shahrood University of Technology, Shahrood, Iran with the code of IR.SHAHROODUT.REC.1403.007. Also, written informed consent was obtained from the participants.

Funding: No funding.

Conflict of Interest: None declared.

References

1. Benjamin DR, Frawley HC, Shields N, van de Water AT, Taylor NF. Relationship between diastasis of the rectus abdominis muscle (DRAM) and musculoskeletal dysfunctions, pain and quality of life: a systematic review. Physiotherapy. 2019;105(1):24-34. doi: 10.1016/j.physio.2018.07.002. PubMed PMID: 30217494 2.
2. Cavalli M, Aiolfi A, Bruni P, Manfredini L, Lombardo F, Bonfanti M, et al. Prevalence and risk factors for diastasis recti abdominis: a review and proposal of a new anatomical variation. Hernia. 2021;25(4):883-890. doi: 10.1007/s10029-021-02468-8. PubMed PMID: 34363190; PubMed Central PMCID: PMC8370915.
3. Mota P, Pascoal AG, Carita AI, Bø K. Normal width of the inter-recti distance in pregnant and postpartum primiparous women. Musculoskelet Sci Pract. 2018;35:34-37. doi: 10.1016/j.msksp.2018.02.004. PubMed PMID: 29494833.
4. Kim S, Yi D, Yim J. The effect of core exercise using online videoconferencing platform and offline-based intervention in postpartum woman with diastasis recti abdominis. Int J Environ Res Public Health. 2022;19(12):7031. doi: 10.3390/ijerph19127031. PubMed

PMID: 35742279; PubMed Central PMCID: PMC9222342.
5. Da Mota PGF, Pascoal AGBA, Carita AIAD, Bø K. Prevalence and risk factors of diastasis recti abdominis from late pregnancy to 6 months postpartum, and relationship with lumbo-pelvic pain. Man Ther. 2015;20(1):200-5. doi: 10.1016/j.math.2014.09.002. PubMed PMID: 25282439.
6. Köckerling F, Botsinis MD, Rohde C, Reinpold W. Endoscopic-assisted linea alba reconstruction plus mesh augmentation for treatment of umbilical and/or epigastric hernias and rectus abdominis diastasis–early results. Front Surg. 2016;3:27. doi: 10.3389/fsurg.2016.00027. PubMed PMID: 27243016; PubMed Central PMCID: PMC4865488.
7. Opala-Berdzik A, Rudek-Zeprzałka M, Niesporek J, Cebula M, Baron J, Gruszczyńska K, et al. Technical aspects of inter-recti distance measurement with ultrasonographic imaging for physiotherapy purposes: the scoping review. Insights Imaging. 2023;14(1):92. doi: 10.1186/s13244-023-01443-4. PubMed PMID: 37202551; PubMed Central PMCID: PMC10195962.
8. Van de Water A, Benjamin DR. Measurement methods to assess diastasis of the rectus abdominis muscle (DRAM): a systematic review of their measurement properties and meta-analytic reliability generalisation. Man Ther. 2016;21:41-53. doi: 10.1016/j.math.2015.09.013. PubMed PMID: 26474542.
9. Jiang Q, Gao Y, Xia S, Gu Y, Gu J, Guo J, et al. Intra-and Interimage reliability of inter-rectus distance measurements determined via ultrasound imaging by the same or different testers in women in the early postpartum period. J Ultrasound Med. 2024;43(6):1037-1044. doi: 10.1002/jum.16430. PubMed PMID: 38380860.
10. Carlstedt A, Bringman S, Egberth M, Emanuelsson P, Olsson A, Petersson U, et al. Management of diastasis of the rectus abdominis muscles: recommendations for Swedish national guidelines. Scand J Surg. 2021;110(3):452-459. doi: 10.1177/1457496920961000. PubMed PMID: 32988320; PubMed Central PMCID: PMC8551433.
11. Benjamin DR, Frawley HJ, Shields N, Peiris C, van de Water AT, Bruder AM, et al. Conservative interventions may have little effect on reducing diastasis of the rectus abdominis in postnatal women–A systematic review and meta-analysis: A systematic review and meta-analysis. Physiotherapy. 2023;119:54-71. doi: 10.1016/j.physio.2023.02.002. PubMed PMID: 36934466.
12. Gluppe S, Engh ME, Bø K. What is the evidence for abdominal and pelvic floor muscle training to treat diastasis recti abdominis postpartum? A systematic review with meta-analysis. Braz J Phys Ther. 2021;25(6):664-675. doi: 10.1016/j.bjpt.2021.06.006. PubMed PMID: 34391661; PubMed Central PMCID: PMC8721086.
13. Vaishnavi G, Mohan Kumar G, Jayson C, Kirupa K, Tharani G, Kamatchi K, et al. Effectiveness of exercise in treating rectus abdominis diastasis. Biomed. 2018;38(4):147-151.
14. Lisnaini L. Effect Of Plank Exercise On Diastasis Recti Abdominis Below Umbilicus In Postpartum Women. International Journal Of Medical and Exercise Science. 2022;8(1):1219-27. doi: 10.36678/IJMAES.2022.V08I01.007.
15. Saleem Z, Khan AA, Farooqui SI, Yasmeen R, Rizvi J. Effect of exercise on inter-recti distance and associated low back pain among post-partum females: a randomized controlled trial. J Family Reprod Health. 2021;15(3):202-209. doi: 10.18502/jfrh.v15i3.7139. PubMed PMID: 34721612; PubMed Central PMCID: PMC8536823.
16. Mota P, Pascoal AG, Carita AI, Bø K. Normal width of the inter-recti distance in pregnant and postpartum primiparous women. Musculoskelet Sci Pract. 2018;35:34-37. doi: 10.1016/j.msksp.2018.02.004. PubMed PMID: 29494833.
17. Acharry N, Kutty RK. Abdominal exercise with bracing, a therapeutic efficacy in reducing diastasis-recti among postpartal females. Int J Physiother Res. 2015;3(2):999-1005. doi: 10.16965/ijpr.2015.122.
18. Radhakrishnan M, Ramamurthy K. Efficacy and challenges in the treatment of diastasis recti abdominis—a scoping review on the current trends and future perspectives. Diagnostics. 2022;12(9):2044. doi: 10.3390/diagnostics12092044. PubMed PMID: 36140446; PubMed Central PMCID: PMC9498119.
19. Park SK, Lee KS, Heo SJ, Jee YS. Effects of High Intensity Plank Exercise on Physical Fitness and Immunocyte Function in a Middle-Aged

Man: A Case Report. Medicina (Kaunas). 2021;57(8):845. doi: 10.3390/medicina57080845. PubMed PMID: 34441051; PubMed Central PMCID: PMC8399219.
20. Park D-J, Park S-Y. Which trunk exercise most effectively activates abdominal muscles? A comparative study of plank and isometric bilateral leg raise exercises. J Back Musculoskelet Rehabil. 2019;32(5):797-802. doi: 10.3233/BMR-181122. PubMed PMID: 30856100.
21. Park S, Choi B-H, Jee Y-S. Effects of plank exercise on respiratory capacity, physical fitness, and immunocytes in older adults. J Exerc Rehabil. 2023;19(6):332-338. doi: 10.12965/jer.2346536.268. PubMed PMID: 38188128; PubMed Central PMCID: PMC10766451.
22. Gupta G, Alok M. Effectiveness of plank exercise in low back pain. International Journal of Science and Research. 2020;9(10):1182-1186. doi: 10.21275/SR201011145832.
23. Sun M, Min L, Xu N, Huang L, Li X. The effect of exercise intervention on reducing the fall risk in older adults: a meta-analysis of randomized controlled trials. Int J Environ Res Public Health. 2021;18(23):12562. doi: 10.3390/ijerph182312562. PubMed PMID: 34886293; PubMed Central PMCID: PMC8657315.
24. Do YC, Yoo WG. Comparison of the thicknesses of the transversus abdominis and internal abdominal obliques during plank exercises on different support surfaces. J Phys Ther Sci. 2015;27(1):169-170. doi: 10.1589/jpts.27.169. PubMed PMID: 25642065; PubMed Central PMCID: PMC4305553.
25. Örgün E, Kurt C, Özsu İ. The effect of static and dynamic core exercises on dynamic balance, spinal stability, and hip mobility in female office workers. Turk J Phys Med Rehabil. 2019;66(3):271-280. doi: 10.5606/tftrd.2020.4317. PubMed PMID: 33089083; PubMed Central PMCID: PMC7557618.
26. Sever O. Comparison of static and dynamic core exercises' effects on stork balance test in soccer players. Journal of Human Sciences. 2017;14(2):1781-91. doi: 10.14687/jhs.v14i2.4440.
27. Cho N, Kim H. Comparison of Effects of Static Core Training and Additional Dynamic Core Training in Young Adults: An Experimental Study. Physical Therapy Rehabilitation Science. 2023;12(1):56-61. doi: 10.14474/ptrs.2023.12.1.56.
28. Awad E, Mobark A, Zidan AA, Hamada HA, Shousha TM. Effect of progressive prone plank exercise program on diastasis of rectus abdominis muscle in postpartum women: a randomized controlled trial. 2021;16(2proc):S395-S403. doi: 10.14198/jhse.2021.16.Proc2.24.
29. A, Raittio L, Helminen O. Revisiting the sample size and statistical power of randomized controlled trials in orthopaedics after 2 decades. JBJS Rev. 2020;8(2):e0079. doi: 10.2106/JBJS.RVW.19.00079. PubMed PMID: 32224628.
30. Thabet AA, Alshehri MA. Efficacy of deep core stability exercise program in postpartum women with diastasis recti abdominis: a randomised controlled trial. J Musculoskelet Neuronal Interact. 2019;19(1):62-68. PubMed PMID: 30839304; PubMed Central PMCID: PMC6454249.
31. Mota P, Pascoal AG, Carita AI, Bø K. The Immediate Effects on Inter-rectus Distance of Abdominal Crunch and Drawing-in Exercises During Pregnancy and the Postpartum Period. J Orthop Sports Phys Ther. 2015;45(10):781-8. doi: 10.2519/jospt.2015.5459. PubMed PMID: 26304639.
32. Kumar R, Zemková E. The effect of 12-week core strengthening and weight training on muscle strength, endurance and flexibility in school-aged athletes. Appl Sci. 2022;12(24):12550. doi: 10.3390/app122412550.
33. Lee J, Jeong K-h, Lee H-, Shin J-y, Choi J-l, Kang S-b, et al. Comparison of three different surface plank exercises on core muscle activity. Phys Ther Rehabil Sci. 2016;5(1):29-33. doi: 10.14474/ptrs.2016.5.1.29.
34. Mueller J, Hadzic M, Mugele H, Stoll J, Mueller S, Mayer F. Effect of high-intensity perturbations during core-specific sensorimotor exercises on trunk muscle activation. J Biomech. 2018;70:212-218. doi: 10.1016/j.jbiomech.2017.12.013. PubMed PMID: 29290418.
35. Kim SY, Kang MH, Kim ER, Jung IG, Seo EY, Oh JS. Comparison of EMG activity on abdominal muscles during plank exercise with unilateral and bilateral additional isometric hip adduction. J Electromyogr Kinesiol. 2016;30:9-14. doi: 10.1016/j.jelekin.2016.05.003. PubMed PMID: 27213781.
36. Yoon J-O, Kang M-H, Kim J-S, Oh J-S. Effect of modified bridge exercise on trunk muscle activity in healthy adults: a cross sectional study. Braz J Phys Ther. 2018;22(2):161-167.

doi: 10.1016/j.bjpt.2017.09.005. PubMed PMID: 28943402; PubMed Central PMCID: PMC5883971.

37. Jung K-S, Cho H-Y, In T-S. Trunk exercises performed on an unstable surface improve trunk muscle activation, postural control, and gait speed in patients with stroke. J Phys Ther Sci. 2016;28(3):940-944. doi: 10.1589/jpts.28.940. PubMed PMID: 27134389; PubMed Central PMCID: PMC4842470.