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Electromyographic Activity of the Rectus Abdominis Muscle during Physical Conditioning Exercises: A Systematic Review

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Abstract**—***Purpose: The rectus abdominis muscle is involved in support, containment of viscera, respiration, defecation, urination, vomiting, and assistance during delivery. Many exercises and equipment are used to strengthen the rectus abdominus muscle, which aim to prevent and rehabilitate low back pain, improve athletic performance, or achieve aesthetic standards. Exercises that potentiate electromyographic activity require the recruitment of the biggest number of muscle fibers and are more effective in developing or maintaining strength. Analysis of electromyographic activity allows us to determine the quality of physical exercises for strength training, and to choose and order them properly in a training session. This systematic review has been developed following the protocol registered in the International Prospective Review Record (PROSPERO) under number CRD42018086172. Methods: To identify relevant studies, we searched for articles in the following databases: MEDLINE, PubMed, Europubmed, SciELO, and Google Scholar. The methodological quality of the studies included in the review and the risk of bias were established based on the Cochrane Handbook of Systematic Reviews of Interventions. Results: After analysis of the full texts, 13 studies were considered eligible in the qualitative synthesis and were included for quantitative analysis. Conclusion: We conclude that electromyographic studies are required, with more rigorous methodological criteria, with the objective of reducing the risk of bias and obtaining definitive conclusions about muscle activity and identifying efficient exercises for the development of the rectus abdominis muscle strength. Ventral plank exercises present better electromyographic results for the rectus abdominis muscle and its action.*
Keywords**—***Abdominal Exercises, Electromyography, EMG, MVIC, Rectus Abdominis.*

I. INTRODUCTION

The abdominal muscles are important in that they are directly related to body posture, containment of viscera, help during expiration, defecation, urination, vomiting, and assisting during delivery [1]. The rectus abdominis muscle is important for the positioning of the pelvis and is related to body posture by being indirectly responsible for the lumbar spine curvature [2]. Weakness of the rectus abdominis muscle can cause several disorders associated with posture, such as ptosis, low back pain, and respiratory disorders [3]–[6].

The rectus abdominis muscle is the main muscle of the anterior wall of the abdomen, characterized by being long and wide, similar to a lane, originating from the symphysis and pubic crest, inserting into the cartilages of the fifth, sixth, and seventh ribs, and xiphoid process of the sternum bone, separated from its homonym by the alba line [7]. The rectus abdominis muscle acts to increase intra-abdominal pressure, trunk flexion, and retroversion of the pelvis[8].

Exercises aimed at abdominal strengthening are widely practiced because they do not only involve aesthetic goals, but also prevent and rehabilitate low back pain, improve athletic performance, and increase resistance and trunk strength for daily activities [9]–[12]

However, a consensus has not yet been reached on exercises that are effective in stimulating the activity of the abdominal muscles, especially the rectus abdominis muscle. Establishing a consensus on this topic would facilitate the dissemination and implementation of standardized training for strength training and physical conditioning, which could result in more effective multi-site training programs, thus improving performance and avoiding injuries in athletes and/or patients.

Decisions on which exercises should be performed in a training program are often based on opinions, personal experiences, and articles that may or may not be based on scientific evidence. Decision-making on which exercises are best under specific circumstances in such a way has led to the use of a wide variety of basic training techniques, with little or no consistency, among strength training specialists. Consequently, exercises that are best suited for activating the abdominal muscles and improving trunk strength are still much debated [13], and yet, there is no evidence-based consensus. Therefore, a systematic review with a consensus on the activity of the rectus abdominis muscle during physical exercises is necessary for specialists in physical conditioning and strength to prescribe appropriate protocols and recommendations to their athletes and patients.

This systematic review aimed to analyze the activation of the rectus abdominis muscle based on the results obtained in electromyographic analyses during the execution of different physical exercises, as well as the morphological and functional characteristics of the volunteers and the technique used in the normalization of the electromyographic signal.

II. MATERIAL AND METHODS

The systematic review protocol of the present study was developed in accordance with the items reported for systematic reviews of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA-P) [14], [15] and registered in the International Prospective Review Record (PROSPERO) under number: CRD42018086172, [16].

1) Study design

It is a protocol for the systematic review of prospective cohort studies, following the guidelines of PRISMA-P. The entire process of study selection is performed by two reviewers and summarized in a PRISMA flow diagram (Fig. 1).

2) Inclusion/exclusion criteria

Cross-sectional studies, case studies, and randomized clinical trials published in English from January 2014 to June 2018 are included in this review.

3) Participants

Healthy individuals who are able to practice physical exercises, aged between 18 and 60 years, were included. No restrictions of gender, ethnicity, or socioeconomic status was applied. We excluded studies with individuals who presented some factor that could interfere in the reliability of the results, such as pregnancy, fracture, osteoporosis, malformations, skeletal deformities, spondylitis/spondylosis, rheumatic diseases, equine tail syndrome, abdominal surgery, tumor, neuromuscular disorders, cardiopathy, neurological dysfunctions, alcoholism, smoking, myopathies, or neuromyopathies, low back pain, abdominal pain or any other type of clinical problem that could interfere with the execution of the proposed exercises.

4) Intervention

Included interventions investigated the electromyographic activation of the rectus abdominis (RA) muscle, regardless of its part, being upper rectus abdominis (URA) or lower rectus abdominis (LRA), and which presented the electromyographic signal normalized by the percentage of maximal voluntary isometric contraction (MVIC%).

5) Results measures

Studies that report the results of the of MVIC% and analysis of the electromyographic signal in the temporal domain of the abdominal musculature in different types of physical exercises are considered. We excluded studies that did not evaluate the MVIC% root mean square (RMS) or those not analyzing the EMG signal in the domain time of the RA muscle. The data collection tools include the analysis of the results obtained through EMG in the exercises performed.

6) Search sources

To identify relevant studies, the following electronic databases are searched: MEDLINE, PubMed, Europubmed, SciELO, Google Scholar. After analyzing

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the main studies, the following keywords were identified for the study: electromyography, electroneuromyography, rectus abdominis, exercises, abdominal muscles (Table 1). Three authors analyzed the title and abstract of the articles. The reference list of relevant studies was examined to identify potential studies to be included.

7)Data collection and analysis

Duplicates are removed, and the references evaluated for eligibility were classified alphabetically, according to the names of the first authors.

Selection process

Two authors independently analyzed the titles and abstracts of the studies identified by the research strategy. Potential eligible studies are reevaluated by reading the full text. In case of disagreement, the opinion of a third author is requested. Following the guidelines (PRISMA-P), a flow chart showed the study selection process (Fig. 1).

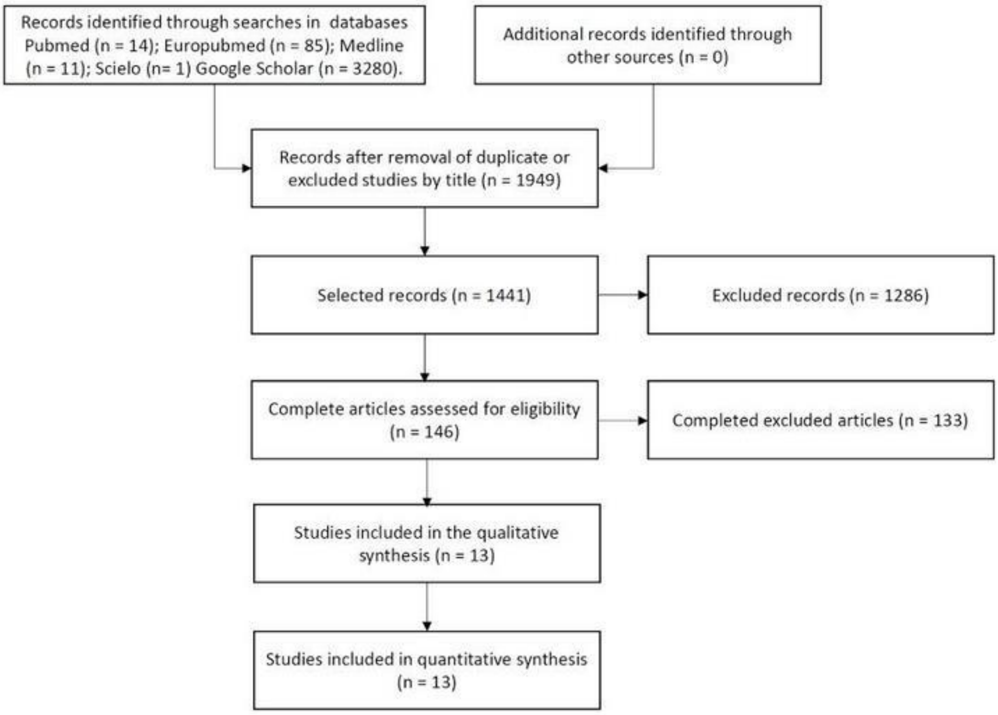

Fig.1. Flow diagram of the study selection process.

8)Data collection process

A reviewer completed the data extraction from the selected studies (study design, year, country, number of participants, volunteer characteristics, age, equipment used, exercise performed, RMS treatment and MVIC%, results, and discussion). A second author verified the accuracy and consistency of all inputs and made relevant clarifications when necessary. A third author mediated possible unresolved disagreements regarding data extraction.

9) Assessment of bias quality and risk of included studies

III. RESULTS

Our search resulted in 3390 citations, and some duplicates were disregarded, leaving 1441 studies that examined the RA muscle. After analyzing titles and abstracts, 146 potentially relevant studies were selected. After analysis of the full texts, 13 studies are considered eligible and are included for further analysis:[18], [19], [20], [21], [22], [23],[24],[25], [26], [27], [28], [29], [30].

A total of 133 studies were considered ineligible, and 42 were excluded that did not study common exercises in physical training, that is, 19 did not clearly analyze the EMG of the RA muscle, 14 measured muscle activity with ultrasonography or magnetic resonance imaging, 2 were not published in the English language, 2 volunteers reported lesions or pain, and 54 EMG signals were not normalized. Data from included studies are presented in Tables 1 and 2.

IV. DISCUSSION

An important finding of this systematic review is that the overall design quality of the included studies is good, but with a risk of methodological bias characterized by a systematic error in the procedures for sample selection and normalization of the EMG signal. Therefore, the evidence base for the EMG activity of the

RA muscle during physical conditioning exercises studied is not strong despite its widespread use in physical training and rehabilitation communities.

Despite the clear risk of methodological bias of the studies that are included in this review, the current data allow us to conclude that physical exercises are more effective in activating the RA muscle. Our findings indicate that the EMG activity of the RA muscle is higher during ventral decubitus exercises, with the trunk in elevation, known as "ventral plank," and is even greater, with the use of equipment that may generate instability, such as the Swiss ball and sling. Possible explanations for the increased activity of the RA muscle during unstable exercises include the increased need for the RA muscle to stabilize the spinal cord and protect the spinal cord, demonstrating the stabilizing functional characteristic of this muscle [31].

Even with the greater tendency of muscular action in ventral plank exercises, no specific type of exercise is considered to be clearly effective for the development of RA muscle strength in this systematic review. The comparisons between the types of exercises show that the findings are conflicting because the values are between 21% [27] and 43% [18] of MVIC for the same exercise, such as the ventral plank, on a stable surface, in the different studies. Escamilla [32]et al. (2010) classified muscle activity level into low (0% to 20% MVIC), moderate (21% to 40% MVIC), high (41% to 60% MVIC), and very high (above 60% MVIC). Exercises that produce muscular activation >60% of MVIC can be directed to muscle strength training, which evidence the low activity of the RA muscle in the exercises analyzed in this review.

In the exercises performed using equipment to generate instability, the EMG values presented ranged from 28% of the MVIC [18] to 141%[20], suggesting a lack of criteria and quality in strategies of EMG signal normalization, using manual resistance, as proposed by [33]. Being that in a test of voluntary isometric maximum contraction, it should have, at most, 100% of the muscular capacity, making values >100% impossible.

To produce a "real maximum" activation, a good fixation of all involved body segments is very important. Untrained individuals may have trouble producing a true level of contraction in the MVIC test. Machines with fastening belts should be used whenever possible. It is interesting to note that, depending on the volunteer's ability to coordinate, different MVIC tests (exercises and different positions) may produce higher MVIC values. Especially for trunk muscles, trying two or three exercises and checking which could have the highest level of EMG signal may be necessary [34].

When manual resistance is used in MVIC tests, it is believed that there is no "peak" activation of the analyzed muscles, leading to lower MVIC values and, automatically, excessive values in the exercises. Therefore, future studies should prioritize the MVIC protocol with fixed resistance to facilitate the understanding and practical application of the results.

The studies included in this review demonstrate characteristics that limit the quality of the results, presenting a strong methodological bias associated with factors, such as the lack of information on the fat percentage of the volunteers, which are present only in the studies of [20], [21] low training time, small samples, little or no familiarization of the volunteers with the proposed exercises, different inclusion and exclusion criteria, as well as lack of discussion about how safe the exercises are, and grouping and summarizing data that understanding the results difficult.

The surface EMG signal amplitude and frequency characteristics have been shown to be sensitive to intrinsic (muscle fiber type, depth, diameter, electrode location, amount of tissue between muscle and electrode) and extrinsic factors (location and orientation about the area and shape of the electrodes, and the distance between them). Therefore, the amplitude of the EMG signal cannot be analyzed directly [35], making it necessary to use a more robust methodology that investigates and standardizes the volunteers morphologically, the percentage of fat, possibly the thickness of the skin fold in the place of fixation of the electrodes, studying individuals trained in the proposed exercises, application of more than one electromyographic evaluation, allowing the observation of the muscular adaptation at the end of a training.

Given the limitations of available scientific literature on this subject, the physical training specialist should review individual studies with caution when interpreting the results for practical applications. We suggest new research using EMG to elucidate the real contributions of the exercises used in gymnasiums and physical training centers for the development of RA muscle strength, bringing the practice methodology closer to the training environment, thus seeking greater validity externality of the information presented, allowing adequate selection and order of the exercises proposed by the coaches, improving the strength training of the RA muscle for different goals and sports modalities.

V. CONCLUSION

The need for electromyographic studies, with more rigorous methodological criteria to reduce the risk of bias and to obtain definitive conclusions regarding muscular activity and to identify efficient exercises for the development of RA muscle strength. Ventral plank exercises present better EMG results for the RA muscle and its action.

The muscle is more required when its activity is associated with instability, but the following should be considered: a) adequate normalization of the EMG signal through equipment that effectively identifies MVIC, b) the morphological characteristics related to the percentage of body fat, c) volunteer familiarization with the proposed exercises. Improved research in this area should provide strength training and fitness specialists with additional evidence-based expertise to enable the prescription of basic exercises appropriate to athletes and patients.

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Table 1. Study inclusion criteria, volunteer characteristics, and electromyographical technique for signal collection.

Author	Inclusion Criteria	Exclusion Criteria	N; sex; age; weight; height. (Median)	Exercise studied familiarization	Isometric Contraction Technique (MVIC)	% Body Fat	EMG Technique; Electrodes Placement (RMS signal analysis)
[18]	Healthy subjects	Low back pain, congenital deformities, orthopedic or neurological disease, superficial injury or pain.	n=23; Sex male/female (14/9); age=29±5; weight=66±12; height 170±7.	Untrained	Manual resistance	Not analyzed	Surface electromyography; MU: 2 cm L L-3. RA: 2 cm L to the umbilical scar; OE: 15 cm L to the umbilical scar; OI: 2 cm B and 2 cm M to the antero-superior iliac crest.
[19]	Healthy subjects	History of spinal cord injury or surgery in the last two years.	n=30; Sex male/female (15/15); age=24±2; weight=71±13; height 170±1.	Experience less than 4 weeks of Yoga.	Manual resistance	Not analyzed	Surface electromyography; The Trigno ™ wireless sensors (Delsys®, Boston, MA) were placed parallel to the muscular womb according to Criswell (2011).
[20]	Physically active subjects, vigorous exercise practitioners twice weekly.	Musculoskeletal pain, neuromuscular disorders, or any form of joint or bone disease.	n=20; Sex male/female(13/7); age=20±1; weight=73±7; height 173±7.	Each subject participated in a familiarization session.	Manual resistance	% Body fat 14.1±4.4%.	Surface electromyography RAS: 2 cm L to umbilical scar; RAI: between the navel and pubic symphysis, 3 cm L of the midline; OBLIQ: between the iliac crest and ribs at an oblique angle; LUMB: L 2 cm from L3 vertebra.
[21]	Physically active subjects, vigorous exercise practitioners twice weekly.	Musculoskeletal pain, neuromuscular disorders, or any form of joint or bone disease.	n=20; Sex male/female (13/7); age=20±1; weight=73±7; height 173±7.	Each subject participated in a familiarization session.	Manual resistance	% body fat: 14.1±4.4.	Surface electromyography RAS: 2 cm L to umbilical scar; RAI: between the navel and pubic symphysis, 3 cm L of the midline; OBLIQ: between the iliac crest and ribs at an oblique angle; LUMB: L 2 cm from L3 vertebra.

[30]	Subjects between 23 and 45 years.	Not analyzed	N=18; Sex male/female (9/9); age= male/female (29.9–6.6 years) (27.7-7.7 years) mass: Male/female (73.3–7.2 kg) and (61.1-7.8 kg) and height: (male/female) (178.1-4.3 cm) and (165.0–7.0 cm).	All subjects became familiar with all exercises during a pre-test that occurred one week prior to the test session.	Manual resistance	Not analyzed	Surface electrodes were positioned on the upper and lower rectus abdominis, external and internal oblique, rectus femoris, dorsal muscle, and lumbar paraspinals.
[22]	Subjects with good health, no pain, no participation in any form of sports and able to perform all exercises safely.	Back or lower back pain, abdominal or spinal surgery.	n=20; Sex male/female (14/6); age=25±7; weight=64±11; height 170±8.	Untrained.	Manual resistance	Not analyzed.	Surface electromyography; RA: 3 cm between the xiphoid process and the umbilicus; OE: above the antero-superior iliac crest at the umbilicus level; OI: 2 cm B and 2 cm M of the anterior superior iliac crest; LP: 3 cm L of the spinous process at the level of L3 and L4.
[29]	Subject must not have neurological or musculoskeletal pathology that could influence exercise.	The subject cannot maintain the correct posture during the plank exercise.	n=20; Sex= male; age 30.44±2.65 years; height, 175.55±5.74 cm; weight 70.33±5.24 kg.	Not analyzed.	Manual resistance	Not analyzed.	Surface electromyography for: RA; HI; ASIC; OE.

[23]	No analyzed.	Complaints of low back pain in the last 6 months; history of neuromuscular or orthopedic disease; presence of severe postural abnormality.	n=20;
			Sex= male/female (10/10);
			age= 20 years;
			weight= No analyzed;
			height= Not analyzed
				Not analyzed.	Manual resistance	Not analyzed.	Surface electromyography: 2 cm lateral to the prickly process of L2 to ES. For RA, 5 cm lateral to the umbilicus; to IO, midway between ASIC and umbilicus; For EO, 15 cm lateral to the umbilicus.

[24]	Healthy adults with no history of surgeries and able to maintain a sitting posture for a minute or longer.	Congenital deformities in the back, orthopedic or neurological problems.	n=7; Sex= male/female (6/1); age=22±2; weight=68±12; height 174±7.	Untrained.	Manual resistance	Not analyzed.	Surface electromyography; OE: 3 cm above the iliac crest; RA: 3 cm L at the navel; ES: 5 cm L to L4.
[25]	Be currently active in resistance training programs	Subject to any prior injuries which, in any way, affect muscle activation.	n=20; Sex= male/female (10/10); age=male/female (25.9±5.61/22.8±1.8 years); height=male/female (175.2±8.5/166.1±8.5 cm); weight=male/female (81.3±6.9/63.0±10.4 kg.	A familiarization period was performed one or two days before the test.	Manual resistance	Not analyzed.	Surface electromyography: RA 2 cm to the right of the umbilicus; OE 15 cm laterally to the umbilicus; EE 2 cm parallel from the L-3 vertebrae. RF was positioned vertically near the midline of the thigh.
[26]	Healthy subject, 20 years old	Individuals with medical problems, abdominal or back surgery histories, psychological problems within 12 months prior to this study.	n=20; Sex= male/female (10/10) age= (male/female) (21.9±1.45/20.7±0.48 years), height=male/female (174.7±3.92/164.7 ±3.2 cm), weight=male/female (66.3±6.24/56.6±3.86 kg)	Not analyzed.	Manual resistance	Not analyzed.	Surface electromyography: RA – 3 cm superior to the umbilicus and 2 cm lateral to the midline; ES-3 cm lateral to the level of the spinous process L4/5; EO - an oblique arrangement above the anterior superior iliac crest and lateral to the umbilicus; IO - midway between the antero-superior iliac crest of the pelvis.
[27]	Do not exercise more than twice per week.	Metabolic, cardiovascular and orthopedic complications in the last year.	n=19; Sex male/female (4/15); age=25±4; weight=52±17; height 161±0.6.	Untrained.	Manual resistance	Not analyzed.	Surface electromyography; RA: 3 cm L to the midline; EO: between the anterior superior iliac crest and the thorax at the umbilicus level; ES: 3.5 cm from the midline at the level of the L2 and L4 vertebrae

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[28]	Absence of neurological and musculoskeletal diseases, with no limitations of movement in the hip and weakness of the lower limb, with no history of surgery in the trunk and lumbo-pelvic region.	Pregnant, elite athletes, subjects with less than 6 months experience in weight training.	n=15; Sex (male/female) (12/3); age=27±3; weight=68±11; height 172±6.	Untrained.	Manual resistance	Not analyzed.	Surface electromyography; IO: 2 cm M to the anterior superior iliac crest; RA: 3 cm L at the navel; ES 3 cm L to L 3; MF L from the midline of the vertebrae, above and posterior to the posterior iliac crest.

n= voluntary's number; cm= centimeters; L= lateral; B= below; M= midline.

Table 2. Exercises and electromyographic activity from rectus abdominis description of the studies included in this systematic review.

Author	Exercises	Rectus Abdominis Muscle EMG* %MVIC
[18]	G1: plank basic position; G2: basic plank with unilateral hip abduction position; SK1: plank with sling resting on both knee positions; SK2: plank position with sling supported on one knee with unilateral hip abduction; AS1: plank with sling resting on both ankle positions; SA2: plank position with sling supported on an ankle and abduction of unilateral hip;	G1: 43.31 (20.99); G2: 46.01 (22.02); SK1: 28.58 (17.39); SK2: 25.69 (15.76); AS1: 54.49 (26.67); AS2: 63.67 (23.08).
[19]	Chair position (Chair); High Plank (Plank); Dog Face Up (Dog); Warrior posture (Warrior).	Chair: 10.6 (7.5); Plank: 28.2 (15.8); Dog: 12.7 (7.6); Warrior: 9.3 (6.7)
[20]	Bilateral suspended supine plank (B.Sus.B.); bilateral stable supine plank (B.St.B.); unilateral suspended supine plank (U.Sus.B.); unilateral stable supine plank (B.St.B.).	B.Sus.B (RAS): 12 (9); (RAI): 7 (10); B.St.B (RAS): 5 (9); (RAI): 1 (10); U.Sus.B (RAS): 15 (9); (RAI): 11 (11); U.St.B (RAS): 7 (9); (RAI): 5 (10).
[21]	Proned stable plank (St.PP); Suspended plank proned (Sus.PP); Stable scroll plank (St.RP); Suspended rolling plank (Sus.RP); Unilateral stable plank (USt.PP); Unilateral suspended proned plank (USus.PP); Standard lateral plank (St.LP); Suspended lateral plank (Sus.LP).	St.PP (RAS): 32 (4); (RAI): 30 (4); Sus.PP (RAS): 131 (15); (RAI): 93 (10); St.RP (RAS): 100 (12); (RAI): 74 (11); Sus.RP (RAS): 145 (22); (RAI) 122 (32); USt.PP (RAS): 30 (5); (RAI): 28 (7); USus.PP (RAS): 43 (9) (RAI): 37 (8); St.LP (RAS): 26 (4); (RAI): 20 (3); Sus.LP (RAS): 31 (5); (RAI): 30 (4).
[30]	A: Prone in the ball with right hip extension; B: Lying on the ball with the extension of the left hip; C: Prone bridge (board) on the ball; D: Prone bridge (plank) on the toes; E: Prone bridge (plank) on the knees; F: lateral crushing on the ball; G: Side bridge (plank) on the toes; H: Side bridge (board) on the knees; I: Crunch; J: Folded abs	A: RAS-43(21); RAI- 44 (11); B: RAS -41 (24); RAI - 39 (19); C: RAS -49 (26); RAI - 48 (9); D: RAS - 34 (15); RAI - 40 (10); E: RAS - 27 (9); RAI - 26 (9); F: RAS - 21 (11); RAI - 16 (7); G: RAS - 26 (15); RAI - 21 (9); H: RAS - 17 (10); RAI - 14 (8); I: RAS - 53 (19); RAI - 39 (16); J: RAS - 40 (13); RAI - 35 (14).
[22]	Trunk flexion in a Swiss ball. (TFSB); Trunk flexion and rolling the in a Swiss ball (TFRSB); Advanced leg stretched dorsal bridge in the Swiss ball (ALSD); Trunk extension in Swiss ball (TESB); Advanced plank (AP); Side bridge (SB); Advanced quadruped (AQ); The trunk back and forth sitting on a chair (FC).	TFSB (0%–20%MVIC); TFRSB (0%–20%MVIC); ALSD (0%–20%MVIC); TESB (0%–20%MVIC); AP (21%–40%MVIC); SB (21%–40%MVIC); AQ (0%–20%MVIC); FC (0%–20%MVIC).

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[29]	Plank; Unilateral isometric hip adduction plank (UIHA); Bilateral isometric hip adduction plank (BIHA).	Plank: RA: Rt (38.83±16.43); Lt (41.16±18.19): Rt (42.47±10.66). UIHA Plank: Rt (46.19±18.19); Lt (55.46±17.51); Rt (55.50±13.14); BIHA Plank:Rt (43.41±20.03); Lt (48.77±18.16); Rt (47.78±12.35).
[23]	Position 1 : conventional bridge exercise ; Position 2 : Bridge exercise; shoulder on the stable table of 1/2 knee height ; Position 3 : Bridge exercise; shoulder on the stable table ; Position 4 : Bridge exercise; shoulder on the sling of 1/2 knee height ; Position 5 : Bridge exercise; shoulder on the sling.	RA: P1(18.79±2.75); P2(27.10±3.030; P3(24.53±3.44); P4(45.05±6.28); P5(41.54±6.20).
[24]	TPE: Plank Exercise; UTPE: Unstable Plank Exercise; MPE: Modified Plank Exercise; UMPE: Unstable Modified Plank Exercise.	TPE: Rt. 34.93 (29.44); Lt. 33.12 (26.62); UTPE: Rt. 39.14 (17.69) Lt. 49.82 (21.79); MPE: Rt. 12.82 (6.69) Lt. 15.44 (7.94); UMPE: Rt. 15.03 (5.82) Lt. 15.10 (8.30).
[25]	Exercise 1: Pike [PK]; Exercise 2: BOSU ball [BOSU] Exercise 3: suspension training device [ST], Exercise 4: Swiss ball [SB], Exercise 5: Core Coaster [CC]).	RA: PK 25.57 6 13.25 BOSU 52.26 6 23.87 ST 55.26 6 18.75 SB 47.59 6 21.28 CC 54.01 6 17.96
[26]	A: Bridge exercise on a stable surface; B: Bridge exercise with shoulder on a stable bench. C: Bridge exercise with shoulder on a sling. D: Bridge exercise with the shoulder on a Swiss ball.	RA: A (18.79±2.75); B(24.53±3.44); C(41.54±6.20); D(31.36±3.73).
[27]	1)High plank exercise performed on three surfaces: Plan (PP); Inclined (PI); Decline (PD). 2)Modified Teaser exercise performed on three surfaces: Plane (TP); Inclined (TI); Decline (TD).	1) PP: (21 e 40% MVIC) PI: (< 21% MVIC); PD: (21 e 40% MVIC); 2) TP: (< 21% MVIC); TI: (41 e 60% MVIC); TD: (< 21% MVIC).
[28]	(BE) Bridge exercise; (SLBE) Single-leg-lift bridge exercise; (SLBU) Single-leg-lift bridge exercise on an unstable surface (SLHB) Single-leg-lift hip abduction bridge exercise.	BE: Right 6.58±3.63, Left 6.90±6.06; SLBE: Right10.78±6.37, Left 8.65±6.06; SLBU: Right11.81±7.01, Left 9.62±6.76; SLHB: Right14.56±9.24, Left 10.32±6.45.