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Original Research Article

Assessment of global abdominal muscle strength and core muscle stability in yoga practitioners between 35-45 years of age: a cross-sectional study

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ABSTRACT

Background: The abdominal wall muscles can be broadly categorized into superficial (global) muscles and deep (local) muscles. Although both components work synergistically. Yoga is a widely practiced intervention that incorporates sustained postures (asanas), dynamic transitions, and isometric contractions. These elements engage both superficial and deep abdominal muscles. This study aims to assess and compare global abdominal muscle strength and core muscle stability in yoga practitioners to better understand their functional relationship.
Methods: We included 70 yoga practitioners from age 35-45 years in our observational cross-sectional study from various yoga centre and community settings. Outcome measures used for assessing core strength was manual muscle testing (MMT) through curl up performance whereas stability was check using pressure biofeedback.
Results: The sample comprised 70 yoga practitioners aged 35-45 years (mean age 40.2 years) with a female predominance (70%). The average BMI was 25.2 kg/m². Participants demonstrated higher global abdominal muscle strength (median grade 4), while core stability was moderate (median level 2).
Conclusions: Higher strength grades showing better stability performance. Therefore, assessment and training programs should include both global strengthening and specific deep core stabilization to achieve comprehensive trunk muscle function.

Keywords: Yoga, Global muscle, Biofeedback, Core stability

INTRODUCTION

Core muscle function, including abdominal muscle strength and neuromuscular stability, plays a crucial role in maintaining spinal stability, postural control, and efficient load transfer during daily and functional activities.[1] The abdominal musculature can be broadly categorized into superficial (global) muscles, such as rectus abdominis, which contribute primarily to trunk movements, and deep (local) stabilizers, such as transversus abdominis, which are responsible for segmental spinal stability and neuromuscular control.[2] Although both components work synergistically, muscle strength and core stability represent distinct constructs. Strength refers to the ability of muscles to generate force, whereas stability involves precise neuromuscular coordination to maintain spinal alignment during movement. Therefore, assessing both components provides a comprehensive understanding of trunk function. Yoga is a widely practiced intervention that incorporates sustained postures (asanas), dynamic transitions, and isometric contractions.[3] These elements engage both superficial and deep abdominal muscles. However, most studies evaluating "core strength" in yoga practitioners use tests such as curl-ups, planks, and endurance tests, which predominantly assess global muscle performance rather than deep core stability. Yoga is commonly recommended for improving strength, flexibility and overall physical fitness. However, the term "core strength" is often used broadly without distinguishing between global muscle strength and deep core stability. Different assessment methods used in literature measure different constructs, leading to inconsistency in interpretation. Yoga practices involve postural holding, controlled movements, and breathing techniques, which may differentially affect superficial and deep core muscles.[4] While superficial muscles may be strengthened through sustained postures, deep stabilizing muscles require specific neuromuscular activation strategies. Furthermore, variability in assessment tools has led to ambiguity in interpreting core muscle performance. There is limited literature that simultaneously evaluates global abdominal muscle strength and core muscle stability using standardized clinical tools. Understanding this distinction is important for physiotherapy assessment, exercise prescription, and rehabilitation planning.

Thus, this study aims to assess and compare global abdominal muscle strength and core muscle stability in yoga practitioners to better understand their functional relationship with the objective of to assess global abdominal muscle strength using Manual muscle testing (MMT) in yoga practitioners, core muscle stability using pressure biofeedback in yoga practitioners and to compare global abdominal muscle strength with core muscle stability in yoga practitioners.

METHODS

Study design and population

Observational study design was employed for the present study with cross-sectional study as a study type. Targeted population of the study was yoga practitioners. The data was collected from the various yoga centers and community settings Maharashtra, India. Inclusion criteria for the study were yoga practitioners aged between 35-45 years, both males and females, individuals practicing yoga for more than 1 year and regular practice for at least 8 weeks, minimum frequency: 2 days/week, 45 minutes per session.[5] Exclusion criteria for the study were Any acute musculoskeletal condition in the last 6 months, pathological conditions such as rheumatoid arthritis, ankylosing spondylitis, Koch's spine, scoliosis, etc.

Neurological conditions like radiculopathy, peripheral neuropathy, history of major surgeries like TKR, THR, spinal surgery, individuals involved in sports activities.

Outcome measure

Global abdominal muscle strength

Assessed using manual muscle testing (MMT) through curl-up performance and graded accordingly. Upper abdominal muscle. Subject supine, with small roll under knees. Then ask him to slowly do curl trunk sit up by first tilting the pelvis posteriorly and flexing the spine, raising in sequence the head shoulder and thorax followed by flexion of trunk towards thigh.[5,6]

Abdominal muscle strength can be graded according to the patient's ability to flex the trunk under progressively more demanding conditions. **Grade 5** is assigned when the patient is able to flex the trunk and maintain trunk flexion while coming into a sitting position with the hands clasped behind the head. **Grade 4** indicates the ability to flex and maintain trunk flexion while coming to a sitting position with the forearms crossed over the chest. **Grade 3** is given when the patient can flex the trunk and maintain trunk flexion while sitting up with the forearms held forward. **Grade 2** represents the ability to flex the trunk with the forearms held forward but without maintaining the flexed position throughout the movement. **Grade 1** is assigned when there is only a palpable or visible contraction of the abdominal muscles during an attempted forward trunk flexion, without producing actual movement.

Core muscle stability

Assessed using a pressure biofeedback unit during Sahrmann's core stability test, evaluating the ability to maintain lumbar stabilization with minimal pressure variation. The inflatable pad of a stabilizer pressure biofeedback unit (PBU) (Chattanooga) was placed under the lumbar spine at approximately L4-L5.[7] While the participant was lying in a crook-supine position, the PBU was inflated to 40 mm Hg. Participants were told to perform the Sahrmann five-level test while drawing-in their abdomen to avoid pressure deviation of more than 10 mm Hg. A deviation of pressure more than 10 mm Hg indicates that the stabilization action of stabilizer muscle has been lost.[8]

Level 1 The participant slowly raised one leg to a position of approximately 90∘ hip flexion with 90∘ knee flexion. The participant then attempted to bring the opposite leg also to the same position in the same manner.

Level 2 From the final position of the previous level, the participant slowly lowered one leg such that the heel contacted the ground/plinth. Then the leg slid out to fully extend the knee.

Level 3 From the end position of level 1, the participant slowly lowered one leg such that the heel reached approximate 12 cm above the ground. Then the leg slid out to fully extend the knee.

Level 4 From the final position of level 1, the participant slowly lowered both legs together such that the heels contacted the plinth. Then the legs slid out to fully extend the knees. Level 5 From the final position of level 1, the participant slowly lowered both legs simultaneously such that the heels reached 12 cm above the ground. The legs then slid out to fully extend the knees.[9]

Sample size determination

At the time of this study, the total population was yoga practitioner were n=70. Hence, a sample size formula, n= $2(Z\alpha + Z\beta)^2 \times \sigma\ 2/d^2$ was used to determine the sample population in this study were (n=sample size, Zα= probability of falsely rejecting a true hypothesis (alpha value), Zβ=probability of failing to reject a false hypothesis (beta value), σ=standard deviation of the outcome or population parameter being studied, d=size of the effect that is clinically worthwhile to detect.) n for yoga practitioners was n=70.

Sampling technique

Purposive sampling technique was used as sampling technique.

Procedure

Participants meeting inclusion and exclusion criteria are recruited. Written informed consent is obtained prior to participation. A self-administered validated questionnaire is used to collect demographic details and information related to yoga practice. Participants underwent assessment of global abdominal muscle strength using manual muscle testing with Curl-up test and core muscle stability using pressure biofeedback unit with Sahrmann levels.

Statistical analysis

The data was entered into Microsoft excel sheet, tabulated and subjected to statistical analysis. Statistical analysis was calculated by using IBM SPSS software and gpower was used to calculate sample size. Mean, standard deviation and non-parametric tests were applied.

RESULTS

Demographic data was taken from the yoga practitioner i.e. age, gender, height, weight, BMI a. The sample comprised 70 yoga practitioners aged 35-45 years with a female predominance (70%). The average BMI was 25.2 kg/m² with mean age of 40.2 years (Table1).

Participants demonstrated higher global abdominal muscle strength (median grade 4), while core stability was moderate (median level 2). Normality was violated for the outcomes ($p<0.001$), supporting the use of non-parametric analyses for objective-based testing (Table 2).

Table 1: Demographic data.

Variables	Mean±SD	Median (IQR)	Min-max
Age (years)	40.2±3.05	40 (4.75)	35-45
Height (cm)	161.7±5.97	160 (5)	147-175
Weight (kg)	65.9±8.32	65 (11)	47-97
BMI (kg/m²)	25.2±2.63	24.4 (3.27)	21.5-34.4
Gender (female)	49 (70.0%)	—	—
Gender (male)	21 (30.0%)	—	—

Values are presented as mean±standard deviation (SD), median (interquartile range (IQR)), or frequency (percentage), SD= Standard deviation; IQR=Interquartile angel; BMI=Body mass index, n=Total number of participants.

Table 2: Global abdominal muscle strength and core stability scores (n=70).

Outcomes (scale)	Mean ±SD	Median	Min–max	Shapiro–Wilk	P value
Global abdominal strength (MMT grade)	3.80 ±0.86	4	2-5	0.866	<0.001
Core stability (Sahrmann level)	2.03 ±0.78	2	1-4	0.838	<0.001

Values are presented as mean±standard deviation (SD), median, frequency (percentage) SD=Standard deviation; MMT: Manual muscle testing n=total number of participants.

Table 3 and table 4 shows distribution of grades/levels for each outcome (n=70). Most participants clustered around Global abdominal muscle strength MMT grade 4 (44.3%) and, while core stability most commonly reached level 2 (44.3%), indicating moderate lumbopelvic control under the test conditions.

Table 5, table 6 and table 7 shows comparison of core stability acroslobal abdominal muscle strength grades (n=70). Core stability differed significantly across global abdominal muscle strength grades ($H(3)=38.30$, $p<0.001$). Post-hoc analysis showed that participants with global abdominal muscle strength grade 5 demonstrated significantly higher core stability than grades 2, 3, and 4, and grade 4 also differed significantly from grade 2.

Table 3: Distribution of grades/levels for each outcome of global abdominal muscle strength (MMT grades) (n=70).

Grades	N (%)
2	5 (7.1)
3	19 (27.1)
4	31 (44.3)
5	15 (21.4)

Table 4: Distribution of grades/levels for each outcome of core stability (n=70).

Levels	N (%)
1	19 (27.1)
2	31 (44.3)
3	19 (27.1)
4	1 (1.4)

Table 5: Comparison of core stability across global abdominal muscle strength grades group-wise core stability (n=70).

Upper abdominal strength (MMT grade)	N	Core stability level: median (IQR)
2	5	1 (1-1)
3	19	2 (1-2)
4	31	2 (2-2)
5	15	3 (3-3)

Values are presented as median (interquartile range [IQR]). MMT=Manual muscle testing; IQR=Interquartile range. Note: higher core stability levels indicate better core stability performance. n=represents the number of participants in each upper abdominal muscle strength grade.

Table 6: Comparison of core stability across global abdominal muscle strength grades overall comparison (Kruskal Wallis) (n=70).

Test	H (DF)	P value	Effect size (ε^2)
Kruskal–Wallis	38.30 (3)	<0.001	0.535

* $p<0.05$ was considered statistically significant.

Table 7: Comparison of core stability across global abdominal muscle strength grades post-HOC comparisons (Dunn test, Holm-adjusted P) (n=70).

Pair (U AB grades)	Z	P (Holm-adjusted)	Significant (p<0.05)
2 vs 3	-1.51	0.13	No
2 vs 4	-2.73	0.019	Yes
2 vs 5	-4.99	<0.001	Yes
3 vs 4	-1.9	0.115	No
3 vs 5	-5.26	<0.001	Yes
4 vs 5	-4.01	<0.001	Yes

*$p<0.05$ was considered statistically significant. Note: Dunn's post-HOC test was performed following a significant Kruskal–Wallis test to identify pairwise differences in core stability among upper abdominal muscle strength grades. Significant differences were observed between grades 2 and 4, grades 2 and 5, grades 3 and 5, and grades 4 and 5.

DISCUSSION

The present cross-sectional study assessed global abdominal muscle strength and core muscle stability among yoga practitioners aged 35-45 years and compared core stability levels across different grades of global abdominal muscle strength. The findings showed that participants had relatively good global abdominal muscle strength, with a mean MMT grade of 3.80±0.86 and median grade of 4, whereas core stability showed a mean Sahrmann level of 2.03±0.78 and median level of 2. This indicates that although the participants demonstrated good global abdominal muscle performance, their deep core stability was only moderate. Therefore, the findings suggest that global abdominal strength and core stability are related but not identical components of trunk function.

The mean value of global abdominal muscle strength indicates that most yoga practitioners were able to perform trunk flexion against moderate resistance. In the present study, 44.3% of participants achieved MMT grade 4 and 21.4% achieved grade 5, showing that nearly two-thirds of the sample had good-to-normal global abdominal strength. This may be attributed to the nature of yoga practice, which involves sustained postures, controlled transitions, balance demands, and repeated isometric activation of trunk muscles. Previous literature has also reported that different yogic postures activate different core muscle groups depending on the trunk and pelvic movement demands of the posture.[10] Electromyographic evidence further supports that selected yoga postures activate the rectus abdominis, abdominal obliques, lumbar extensors, and gluteal muscles, which may explain the better global abdominal strength observed in the present sample.[11]

In contrast, the mean core stability score findings of 2.03±0.78 suggest that most participants had only moderate lumbopelvic control. In the present study, 44.3% of participants achieved Sahrmann level 2, while only 1.4% reached level 4 and none reached level 5. This indicates that although the participants could perform basic stabilization tasks, most were unable to maintain adequate lumbar control during higher-level lower-limb loading tasks. Core stability depends not only on strength but also on neuromuscular coordination, timing, endurance, and controlled activation of the deep stabilizing muscles such as the transversus abdominis, internal oblique, multifidus, pelvic floor, and diaphragm.[12] Therefore, moderate Sahrmann scores despite good MMT grades suggest that routine yoga practice may improve global abdominal performance over advanced deep core stabilization. This interpretation is supported by Shiraishi and Bezerra, who reported improvement in abdominal muscular endurance following a six-week yoga program in young women, and by Petrič et al, who found that hatha yoga incorporating segmental stabilization principles improved trunk muscle endurance in healthy adults.[13,14] However, Petrič et al also reported no significant improvement in endurance ratios, suggesting that improved endurance does not always translate into balanced or advanced lumbopelvic control. In a case study that analysed the effects of yoga and core stabilisation in mechanical low back pain and its functional outcomes, the results showed that while both interventions demonstrated benefits, core stabilisation exercises showed superior outcome in core muscle endurance while the effects of yoga were explained by the biopsychosocial factors rather than relative increase in core strength and stability.[15]

This finding is clinically important because pressure biofeedback and Sahrmann testing assess a different construct from curl-up-based strength testing. Pressure biofeedback has been described as an indirect method to evaluate transversus abdominis activity and to monitor progress in trunk stabilization programs.[16] The Sahrmann test progressively increases the demand on abdominal control by requiring the participant to maintain lumbar stability while moving one or both lower limbs. EMG-based research on the Sahrmann five-level test has shown that abdominal muscle activity differs across levels, with higher levels requiring greater abdominal activation than lower levels.[17] Thus, the predominance of level 2 performance in the present study suggests that the participants had basic stabilization capacity but limited ability to sustain control during more advanced stabilization tasks. When core stability was compared across different grades of global abdominal muscle strength, a clear functional pattern was observed. Participants with higher abdominal strength grades demonstrated better ability to maintain lumbopelvic control during the Sahrmann test. This suggests that adequate global abdominal strength may provide a supportive foundation for core stability; however, it does not fully explain stabilization capacity during limb movement.

The comparison also shows that improvement in global strength does not automatically indicate equivalent improvement in core stability. Although participants with higher MMT grades generally performed better on the Sahrmann test, the overall median core stability level remained moderate. This supports the concept that superficial/global abdominal muscles are mainly responsible for trunk movement and force production, whereas deep/local stabilizers are responsible for segmental control and lumbopelvic stability.[18] Therefore, a yoga practitioner may perform well during a curl-up task but may still have difficulty maintaining lumbar pressure control during progressive lower-limb movement. The findings are consistent with existing literature showing that yoga can improve muscular fitness, but the effect may vary depending on the component assessed.[19] A 12-week Hatha yoga intervention reported improvements in muscular strength, endurance, and flexibility among adults, supporting the role of yoga in improving general physical fitness.[20] However, the present study adds that "core strength" should not be interpreted as a single construct. Global abdominal strength and core stability should be assessed separately because they represent different aspects of trunk function.[21] From a physiotherapy perspective, these findings suggest that yoga practitioners with good abdominal strength may still benefit from specific deep core stabilization exercises. Exercises such as abdominal drawing-in, pressure biofeedback training, pelvic control drills, dead bug progressions, and graded Sahrmann-level exercises may help improve neuromuscular control of the deep stabilizers. This is particularly relevant in rehabilitation, postural correction, low back pain prevention, and exercise prescription, where both strength and stability are necessary for optimal trunk function. The study has certain limitations.[22] As it was cross-sectional, causal conclusions cannot be drawn. The use of purposive sampling may limit generalizability. The study also did not include a non-yoga control group, and factors such as type of yoga, duration of practice, frequency, intensity, and specific asana exposure were not analyzed separately. Future studies should compare yoga practitioners with non-practitioners and evaluate whether adding specific core stabilization training to yoga produces greater improvements in Sahrmann levels.

CONCLUSION

Yoga practitioners aged 35-45 years demonstrated good global abdominal muscle strength but only moderate core stability. Core stability differed significantly across global abdominal muscle strength grades, with higher strength grades showing better stability performance. Therefore, assessment and training programs should include both global strengthening and specific deep core stabilization to achieve comprehensive trunk muscle function.

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