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Comparison Of Trunk Muscle Endurance And Modified Oswestry Disability Levels In Female Recreational Badminton Players With Low Back Pain

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Abstract:
Background: *Badminton requires rapid trunk rotations and dynamic core stability to accommodate frequent changes in body position. While trunk muscle endurance has been linked to low back pain (LBP) in the general population, there remains a significant gap regarding its association with LBP in overhead sports athletes, particularly female recreational badminton players. This study investigated the relationship between trunk muscle endurance and functional disability in female recreational badminton players with low back pain.*
Materials and Methods: *A cross-sectional study was conducted on 128 female recreational badminton players aged 18-40 years with low back pain lasting more than 4 weeks. Participants were recruited through convenience sampling from badminton clubs. Trunk muscle endurance was assessed using endurance tests: trunk flexor endurance (FLEX), trunk extensor endurance (EXT), right and left side planks (RSB, LSB), and right and left flexion-rotation tests. Functional disability was measured using the Modified Oswestry Disability Index (ODI). Statistical analysis was performed using IBM SPSS v29, with independent t-tests and Pearson's correlation coefficient to evaluate relationships between variables.*
Results: *The study included 128 participants with a mean age of 25.8 ± 6.2 years. The majority (66.41%) experienced minimal disability, while 33.59% had moderate disability according to ODI scores (mean: 15.31 ± 9.38%). Trunk flexor endurance was higher in the minimal disability group (77.14 ± 23.14 seconds) compared to moderate disability (69.51 ± 19.17 seconds), with borderline significance (p = 0.0649). Right flexion-rotation endurance showed a significant difference (p = 0.0313), being higher in the moderate disability group. Correlation analysis revealed a significant positive correlation between right flexion-rotation endurance and ODI scores (r = 0.1741, p = 0.0494).*
Conclusion: *While overall trunk endurance did not differ significantly between minimal and moderate disability groups, our results point toward subtle but clinically relevant asymmetries, particularly in rotational endurance. These asymmetries may contribute to perceived disability through inefficient or compensatory motor strategies. Thus, rehabilitation strategies in NSLBP, especially in racquet sport athletes, should go beyond general core strengthening and include movement-specific and side-specific endurance training to address the root of dysfunction.*
Key Words: *Badminton, Trunk Muscle Endurance, Low Back Pain, Core Stability, Oswestry Disability Index, Female Athletes.*

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I. Introduction

Badminton participation has increased by 22% from 2006 to 2016, with more than 200 million participants worldwide.[1] As the fastest racquet sport, with shuttlecocks reaching speeds exceeding 300 km/h, badminton demands exceptional physical capacities including dynamic core stability, rapid directional changes, and powerful trunk rotations.[2] Modern adaptations have intensified the sport's physical demands through jumps, lunges, and unanticipated directional changes, subjecting athletes' joints to high ground reaction forces on hard court surfaces. The trunk serves as the vital link between upper and lower limb function, with trunk muscles playing key roles in spinal control and force dissipation. During power shots, large forces generated from the upper limb must be safely transferred through the trunk to the legs. [4] Key trunk muscles such as the multifidus, transversus abdominis, and quadratus lumborum have been shown to play important stabilizing roles, and imbalances between these structures contribute to low back pain development. [5]

Previous studies indicate that badminton players commonly report shoulder pain (27.6%) and lower back pain (35.4%). [6] in recreational players, significant associations exist between shoulder pain, lower back pain, and knee pain, where pain in one anatomical site produces compensatory loads affecting the other two sites. [7]

Concerning, one-third of badminton players with low back pain continue practicing, potentially increasing injury risk.

Assessment of trunk extensor muscle endurance is crucial, as deficits and imbalances between trunk muscle groups are primary risk factors for low back disorders and can negatively affect sports performance. [8] While expensive laboratory-based tests exist (force platforms, isokinetic dynamometers), isometric torso muscle endurance tests following McGill's methods are more clinically practical and cost-effective. [9]

Despite the increasing participation of females in competitive badminton, limited research focuses specifically on this population. Females often present with different musculoskeletal characteristics, including lower trunk muscle mass and different pelvic biomechanics, necessitating gender-specific examination. [10] Understanding the relationship between trunk endurance and back dysfunction in female badminton players may help identify risk factors and inform targeted rehabilitation strategies.

II. Material And Methods

Study Design: Cross-sectional study
Study Setting: Badminton clubs and recreational centers
Study Location: Mumbai
Study Duration: 6 months
Sample size: 128 female recreational badminton players
Sample size calculation: A sample size calculation was performed using G*Power 3.1.9.4 for a one-sample t-test.

A significance of α = 0.05, and statistical power (1–β) = 0.95 was desired. The analysis indicated that a minimum total sample size of 122 participants would be required to detect the expected effect.

Subjects & Selection Method:

Female recreational badminton players were recruited through convenience sampling from various badminton clubs and recreational centers.

Inclusion Criteria:

1) Female recreational badminton players aged 18 to 40 years
2) Playing badminton at least 3 times per week (minimum 3 hours/week)
3) History of nonspecific low back pain for more than 4 weeks
4) Willing to participate and provide informed consent

Exclusion Criteria:

1) Recent history of spinal surgery or traumatic back injury
2) Diagnosed with specific causes of LBP (disc herniation, scoliosis, spondylolisthesis)
3) Presence of neurological symptoms (tingling, numbness, radiating pain)
4) Professional/elite level athletes

Procedure methodology

Ethical approval was obtained from the Institutional Ethics Committee. Participants were screened for eligibility, and informed consent was obtained. Demographic details including age, height, weight, years of badminton play, training frequency, and pain duration were recorded using a structured questionnaire. Relevant health history and exclusion criteria were screened, followed by administration of the Modified Oswestry Disability Index and trunk muscle endurance tests.
Endurance tests.

Outcome Measures:

1. Modified Oswestry Lower Back Disability Index (ODI):

A 10-item questionnaire assessing self-reported symptoms and functional limitations due to low back pain. Items include pain intensity, personal care, lifting, walking, sitting, standing, sleeping, social life, and travel. Scoring ranges from 0-100%, with higher scores indicating greater disability.

2. Trunk Muscle Endurance Tests:

I. Trunk Flexor Endurance (FLEX): Participant maintains 60° trunk flexion from supine position

II. Trunk Extensor Endurance (EXT): Biering-Sørensen test maintaining horizontal trunk position

III. Right and Left Side Planks (RSB, LSB): Lateral bridge position maintenance

IV. Right and Left Flexion-Rotation: Sit-up position with rotation maintenance

All tests measured endurance time in seconds, with participants instructed to maintain positions until fatigue or form failure.

Statistical analysis

Data analysis was performed using IBM SPSS version 29. Descriptive statistics were calculated for all variables. Independent t-tests compared trunk endurance between minimal and moderate disability groups. Pearson's correlation coefficient examined relationships between ODI scores and endurance measures. Statistical significance was set at $p < 0.05$.

III. Result

A total of 128 female recreational badminton players completed the study (mean age: 25.8 ± 6.2 years). Participants had been playing badminton for 4.8 ± 3.2 years on average. The majority (66.41%) experienced minimal disability (ODI < 20%), while 33.59% had moderate disability (ODI 20-40%). No participants reported severe or complete disability. Demographic characteristics showed significant associations with disability levels (Table 1).

Younger players (≤20 years) and those with normal/underweight BMI were more likely to have minimal disability. Players with 1-2 years of experience showed the least disability. Training frequency (days per week) and session duration showed significant associations with disability levels ($p < 0.05$), with increased frequency and longer sessions linked to higher moderate disability.

Trunk muscle endurance values (Table 2) showed mean trunk flexor endurance of 74.58 ± 22.11 seconds, trunk extensor endurance of 56.41 ± 12.27 seconds, and side plank endurance of 75.27 ± 25.34 seconds (right) and 67.70 ± 15.04 seconds (left). Comparison between disability groups (Table 3) revealed trunk flexor endurance was higher in minimal disability (77.14 ± 23.14 seconds) versus moderate disability (69.51 ± 19.17 seconds), approaching significance ($p = 0.0649$). Right flexion-rotation endurance was significantly higher in moderate disability (97.23 ± 32.06 seconds) compared to minimal disability (84.29 ± 31.58 seconds, $p = 0.0313$).

Correlation analysis (Table 4) showed a significant positive correlation between right flexion-rotation endurance and ODI scores ($r = 0.1741$, $p = 0.0494$). Other endurance measures showed weak, non-significant correlations with disability scores.

Table 1: Demographic Data

Factors	Levels of disability				Total	Chi-square	p-value
	Minimal	%	Moderate	%			
Age groups							
<=20yrs	16	80.00	4	20.00	20	4.4040	0.1110
21-30yrs	49	69.01	22	30.99	71		
>=31yrs	20	54.05	17	45.95	37		
BMI							
Underweight	14	77.78	4	22.22	18	2.7920	0.4250
Normal	32	71.11	13	28.89	45		
Overweight	24	58.54	17	41.46	41		
Obese	15	62.50	9	37.50	24		
Years of playing							
1-2yrs	16	88.89	2	11.11	18	5.8630	0.2100
3-4yrs	25	58.14	18	41.86	43		
5-6yrs	20	62.50	12	37.50	32		
7-8yrs	17	70.83	7	29.17	24		
>=9yrs	7	63.64	4	36.36	11		
Days / week							
3weeks	30	56.60	23	43.40	53	17.4660	0.001*
4weeks	53	80.30	13	19.70	66		
5weeks	2	40.00	3	60.00	5		
6weeks	0	0.00	4	100.00	4		
Session duration (hours/week)							
3weeks	3	100.00	0	0.00	3	12.1050	0.007*
4weeks	63	74.12	22	25.88	85		
5weeks	13	41.94	18	58.06	31		
6weeks	6	66.67	3	33.33	9		
Pain duration (weeks)							
1-4weeks	8	66.67	4	33.33	12	1.3230	0.7240
5-8weeks	47	62.67	28	37.33	75		
9-12weeks	25	73.53	9	26.47	34		
>=13weeks	5	71.43	2	28.57	7		
Total	85	66.41	43	33.59	128		

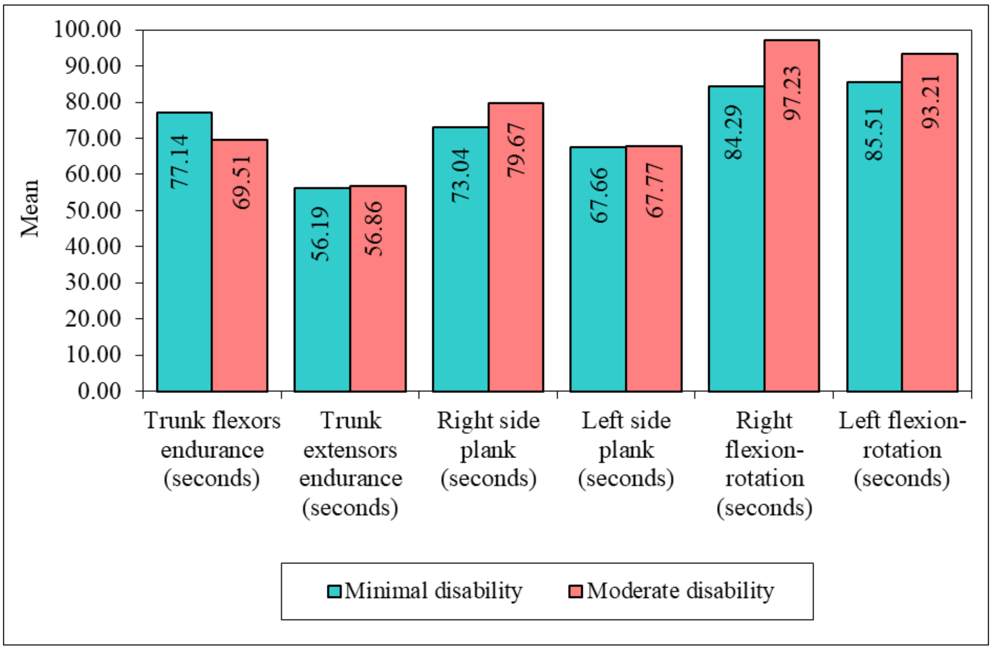

Figure 1: Comparison of levels of disability with trunk muscle endurance scores

Table 2: Summary of all variables

Variables	Minimum	Maximum	Mean	Std.Dev.
Modified Oswestry Index (%)	2.00	40.00	15.31	9.38
Trunk Flexors Endurance (seconds)	26.00	145.00	74.58	22.11
Trunk Extensors Endurance (seconds)	34.00	94.00	56.41	12.27
Right Side Plank (seconds)	20.00	154.00	75.27	25.34
Left Side Plank (seconds)	17.00	136.00	67.70	15.04
Right Flexion-Rotation (seconds)	40.00	163.00	88.64	32.21
Left Flexion-Rotation (seconds)	36.00	168.00	88.09	33.41

Table 3: Comparison of levels of disability with trunk muscle endurance scores by independent-t test

Trunk muscle endurance	Minimal disability		Moderate disability		t-value	p-value
	Mean	SD	Mean	SD		
Trunk flexors endurance (seconds)	77.14	23.14	69.51	19.17	1.8620	0.0649
Trunk extensors endurance (seconds)	56.19	12.48	56.86	11.98	-0.2917	0.7710
Right side plank (seconds)	73.04	26.56	79.67	22.39	-1.4053	0.1624
Left side plank (seconds)	67.66	15.36	67.77	14.58	-0.0384	0.9694
Right flexion- rotation (seconds)	84.29	31.58	97.23	32.06	-2.1782	0.0313*
Left flexion- rotation (seconds)	85.51	33.58	93.21	32.86	-1.2346	0.2193

Table 4: Correlation between Modified Oswestry Index (%) with trunk muscle endurance scores by Karl Pearson's correlation coefficient Variable

Correlation between Modified Oswestry Index (%) with trunk muscle endurance scores by Karl Pearson's correlation coefficient Variable	Correlation between Modified Oswestry Index (%) with		
	r-value	t-value	p-value
Trunk flexors endurance (seconds)	-0.0455	-0.5115	0.6099
Trunk extensors endurance (seconds)	0.1073	1.2110	0.2282
Right side plank (seconds)	0.1358	1.5381	0.1265
Left side plank (seconds)	-0.0380	-0.4266	0.6704
Right flexion-rotation (seconds)	0.1741	1.9844	0.0494*
Left flexion-rotation (seconds)	0.0562	0.6318	0.5287

*p<0.05

IV. Discussion

This study aimed to compare trunk muscle endurance with the levels of disability as measured by the Modified Oswestry Disability Index (ODI) and the trunk muscle endurance tests in female recreational badminton players with nonspecific low back pain (NSLBP). While Trunk muscle endurance has been extensively studied in various sports but the correlation of trunk muscle in athletes with low back pain there has been limited research on badminton players as well. Trunk musculature is predominantly type I muscle fibers and appear to become more anaerobic as a result of deconditioning common in recreational players.

Our results revealed that mean trunk flexor endurance was slightly higher in players with minimal disability (77.14 seconds) compared to those with moderate disability (69.51 seconds), with a p-value ($p = 0.0649$). While not statistically significant, this finding suggests a potential trend: individuals with better core stability may experience less functional limitation, consistent with prior research that links core endurance with spinal stability and reduced LBP symptoms.

Interestingly, the right flexion-rotation endurance was significantly higher in the moderate disability group (97.23secs) than in the minimal group (84.29secs), with a p-value of 0.0313. This counterintuitive result may reflect compensatory overuse of certain trunk muscles due to asymmetrical movement patterns or side dominance, which is common in racquet sports like badminton. It might also suggest protective guarding mechanisms or altered motor strategies in those with higher disability. Even Trunk flexor endurance showed a negative correlation with ODI scores ($r = -0.0455$). This aligns with McGill et al.'s theory that trunk flexors play a central role in stabilizing the spine during dynamic tasks, and their deconditioning can increase vulnerability to low back pain. The right flexion-rotation endurance ($r = 0.1741$, $p = 0.0494$), again positively correlated with disability, indicating that higher endurance in this movement was associated with greater perceived disability. This result could imply that despite increased endurance, the movement might be biomechanically inefficient or compensatory in nature, potentially exacerbating symptoms. The side planks, which assess lateral trunk endurance, did not correlate significantly with ODI scores. However, the right-side plank showed higher endurance values than the left on average (75.27secs vs 67.70secs), possibly indicating muscular asymmetry, which may contribute to or result from LBP. The higher right-sided endurance might be indicative of dominant-hand use in overhead shots, further supporting the need for unilateral endurance assessment and correctional training. In this study, trunk extensor endurance did not show a significant difference between the minimal disability group (56.19 ± 12.48 seconds) and the moderate disability group (56.86 ± 11.98 seconds), with a p-value of 0.7710. Studies by Biering-Sørensen (1984) and later by Demoulin et al. (2006) have consistently demonstrated that individuals with chronic LBP exhibit reduced trunk extensor endurance, as measured by tests like the Sorensen hold. Lower endurance in these muscles has been linked to greater disability and higher recurrence of LBP.

Considering that the participants in this study were novice female badminton players, it is important to account for the biological variables between the sexes. The anatomical and physiological characteristics of females namely greater anterior pelvic tilt, wider pelvis dimensions, and increased lumbar lordosis compared to males, can affect spinal alignment and core muscle activation patterns during physical activity. These may predispose them to altered load distribution in the lumbar spine, especially in dynamic sports like badminton that involve frequent lunging and rotational movements. Additionally, hormonal influences of particularly estrogen and relaxin during the menstrual cycle leads to increased ligament laxity potentially impairing neuromuscular control during athletic tasks. [10]

For novice players, who often lack regular core conditioning training and may have undeveloped neuromuscular control, these biological variables may heighten the risk of mechanical inefficiency and injury. Moreover, studies have shown that females generally possess lower trunk muscle strength and endurance compared to males due to differences in muscle fiber composition and cross-sectional area.

These sex-specific factors when combined with the physical demands of badminton and a novice training background likely contributed to the variability in trunk muscle endurance observed in this study, and may explain why endurance did not strongly correlate with perceived disability in many measures. Therefore, core strengthening and neuromuscular training should be considered essential components of early intervention and injury prevention in novice female badminton athletes.

V. Conclusion

While overall trunk endurance did not differ significantly between minimal and moderate disability groups, subtle asymmetries in rotational endurance were identified. The higher right flexion-rotation endurance in the moderate disability group suggests compensatory motor strategies that may contribute to perceived disability. These findings indicate that rehabilitation strategies for nonspecific low back pain in racquet sport athletes should extend beyond general core strengthening to include movement-specific and side-specific endurance training addressing the root of dysfunction.

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