

Influence of Deep Abdominal Flexor Muscle Recruitment on Dynamic Balance and Gait Speed in Middle-Aged Tailors

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Abstract:-

➤ Background

51.67% of Indian tailors reported having lower back discomfort; this could be related to the extended sitting positions they used while doing different repetitive and boring tasks for their jobs. An essential component of anticipatory postural regulation is the transversus abdominis. Elevated levels of lactic acid are caused by tiredness in the trunk muscles, which impairs both static and dynamic balance. Regardless of the direction of movement, the Transversus Abdominis, a trunk stabilizer, is necessary for a functional and efficient gait. Hence, the purpose of the study is to estimate the influence of deep abdominal flexor muscle recruitment on dynamic balance and gait speed in middle-aged tailors.

➤ Objective

To estimate the deep abdominal flexor muscle recruitment in prolonged sitting and the relationship of impaired deep abdominal flexor muscle recruitment with dynamic balance and gait speed in middle-aged tailors.

➤ Method

A total number of 33 middle-aged tailors were recruited from tailoring units and garment stations fulfilling the inclusion criteria were recruited for the study after attaining the informed consent. Each of the subjects were asked to do prone test to record their deep abdominal flexor muscle recruitment. 27 of the total tailors showed decreased deep abdominal flexor muscle recruitment. They performed the functional reach test and 4 meter gait speed to assess their dynamic balance and gait speed.

➤ Results and Discussion

The statistical analysis of the data was done by bivariate analysis. There is a weak negative correlation between prolonged sitting and deep abdominal flexor muscle recruitment ($p > 0.05$). There is a weak positive linear relationship between dynamic balance and impaired deep abdominal flexor muscle recruitment, whereas a negligible positive linear relationship exists between gait speed and impaired deep abdominal flexor muscle recruitment. Evidence states that delayed onset of Transversus Abdominis activation leads to inefficient muscular stabilization of the spine and compromised balance. As a result, the effort exerted by the trunk muscles must be altered to control spinal movements and maintain an optimal posture. A weaker Transversus Abdominis result in a lower gait speed and may contribute to an inactive life and further weakening of the muscle strength and a high risk of falling.

➤ Conclusion

The study concluded that there is a relationship between deep abdominal flexor muscle recruitment and prolonged sitting. Along with that, impaired deep abdominal flexor muscle recruitment has an influence on dynamic balance and gait speed in middle aged tailors.

Keywords:- Deep Abdominal Flexor Muscle; Dynamic Balance; Gait Speed; Tailors; Prolonged Sitting; Transversus Abdominis.

I. INTRODUCTION

Tailors are garment workers who undertake a variety of repetitive and monotonous tasks while seated at their desk. Musculoskeletal discomfort is a result of work settings with poor ergonomic features, such as restricted postures, repetitive motions, and severe visual demands, according to research done on working conditions and related issues in the garment workstation units. This causes issues with their lower limbs, back, shoulder, and neck. 51.67% of Indian tailors

reported having lower back discomfort; this could be related to the extended sitting positions they used while doing different repetitive and boring tasks for their jobs.¹

Core muscles are described as a kinetic link facilitating transfer of angular momentum and torques between both the upper and lower limbs during occupational skills, sports skills, and activities of daily living.² Recent evidence from studies has suggested that the deep intrinsic muscles of the spine such as Transversus Abdominis (TrA) and Multifidus (MF) provide an important and distinct contribution to the control of lumbo-pelvic stability at an intersegmental level.³

Working in seated position exposes a large proportion to the risk of developing sitting-related musculoskeletal complaints.⁴ Recent studies indicated that prolonged sitting leads to low back discomfort and lumbo-pelvic muscle fatigue.⁵ Efficient control of the Center of Mass (COM) through proper muscle activation is necessary to maintain good equilibrium in both sitting and standing.⁶ An increased trunk muscle fatigue led to increased lactic acid levels and impaired static and dynamic balance, thereby resulting in decreased abdominal muscle thickness and poorer dynamic balance.^{7,8} Reduced core stabilisation and abdominal pressure by TrA, as well as reduced limb muscles strength, leads to imbalance.⁹ Securing the stability of the trunk is deeply involved in the distal movement and the quality of gait. For an effective and efficient gait, the action of TrA- the trunk stabilizer is essential regardless of the direction of movement.¹⁰

The prevalence of work related musculoskeletal discomforts has been high due to the characteristics of tailoring activities. Prolonged sitting in awkward postures is not uncommon and is often accompanied with seats that have no backrests in tailors. The activation of TrA was reduced in people who have to sit for prolonged period of time. This change in posture for long duration leads to decreased recruitment of local trunk stabilizers which affects the spinal stability, in turn leading to LBP. Moreover, tailors get engaged in ample working hours yet not realize the musculoskeletal discomfort and risks associated with their tasks, poorly designed workstation and awkward working postures. A weaker TrA result in a lower gait speed and may contribute to an inactive life and further weakening of the muscle strength and a high risk of falling. The TrA has multiple functions like stabilization of pelvis and spine and anticipatory postural control, but how these functions are coordinated has received limited attention. However, there is paucity of literature that discusses about the influence of deep abdominal flexor muscle recruitment on dynamic balance and gait speed in middle-aged tailors. Hence, the purpose of the study is to estimate the influence of deep abdominal flexor muscle recruitment on dynamic balance and gait speed in middle aged tailors.

II. MATERIALS AND METHODS

An analytical cross-sectional study was conducted with convenience sampling technique for a duration of six months to estimate the relationship between deep abdominal flexor muscle recruitment in prolonged sitting and the influence of impaired deep abdominal flexor muscles recruitment on dynamic balance and gait speed in middle-aged tailors.

After obtaining clearance from the Scientific Committee and Institutional Review Board, a total number of 33 tailors from tailoring units and garment stations fulfilling the inclusion criteria were recruited for the study after attaining the informed consent. Each of the subjects were asked to do prone test to record their deep abdominal flexor muscle recruitment. 27 of the total tailors showed decreased deep abdominal flexor muscle recruitment. They performed the functional reach test and 4 meter gait speed to assess their dynamic balance and gait speed. Both male and female tailors aged between 44 to 59 years with BMI 18.5- 29.9 and assuming prolonged sitting for at least 2 hours/day continuously for minimum 3 days a week and with a Metabolic equivalent 600-3000 in Global Physical Activity Questionnaire (GPAQ) were included in the study. Subjects with history of spinal fracture or spinal surgery, back pain and shoulder pain, spinal deformities such as scoliosis, lordosis, kyphosis, etc., history of abdominal surgeries, degenerating and inflammatory musculoskeletal diseases, pregnancy, upper and lower limb deformities and decreased range of motion in the joints, vestibular and neurological dysfunction, participating in regular physical exercise, inability to maintain prone position and psychiatric and non-cooperative patients.

III. PROCEDURE

After obtaining clearance from the Scientific Committee and Institutional Review Board, a total number of 33 tailors from tailoring units and garment stations fulfilling the inclusion criteria were recruited for the study after attaining the informed consent. Each of the subjects was asked to do prone test to record their deep abdominal flexor muscle recruitment using pressure biofeedback unit (PBU). Out of the total tailors, those showed decreased deep abdominal flexor muscle recruitment were asked to performed the functional reach test (FRT) and 4 meter gait speed (4MGS) to assess their dynamic balance and gait speed.

IV. RESULTS

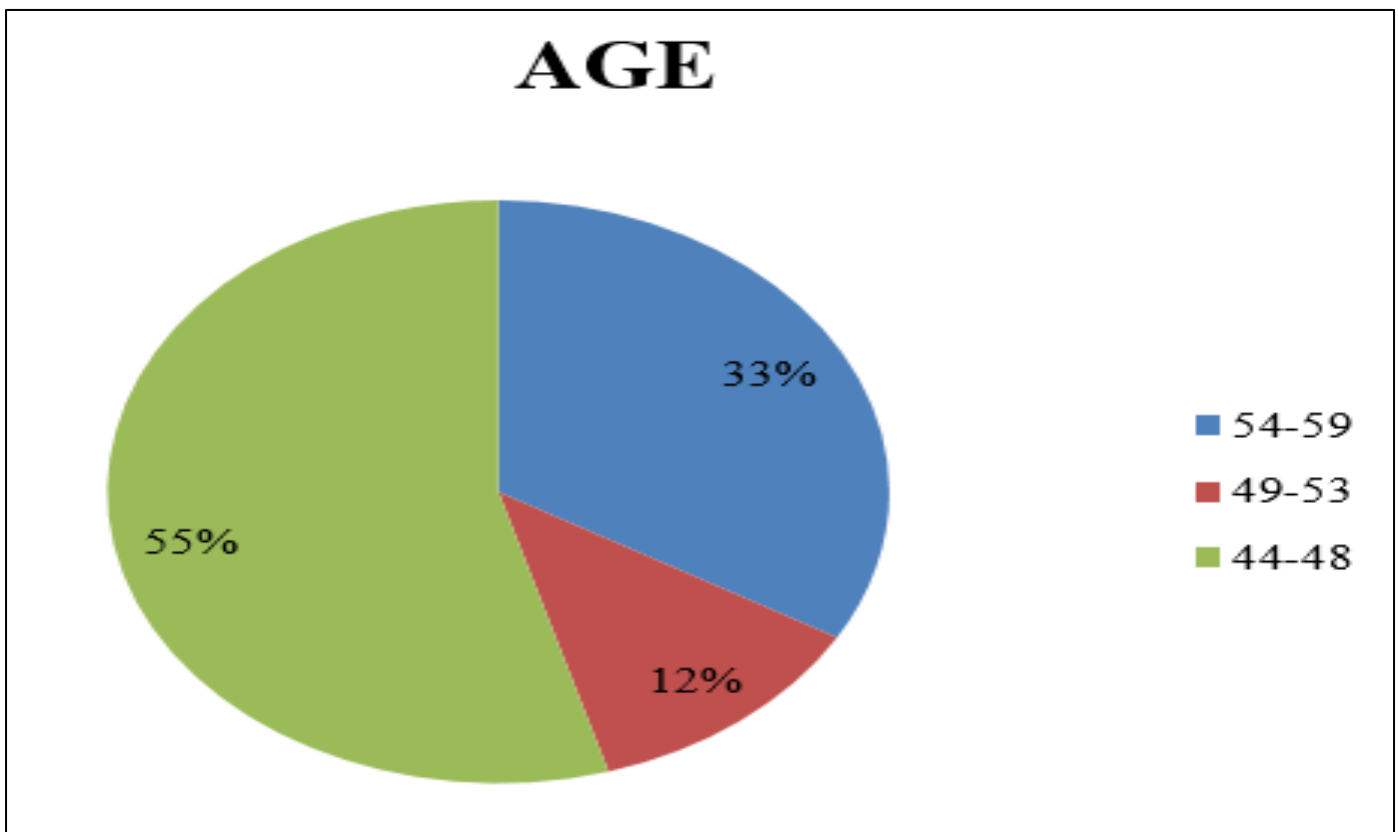
The obtained data was analysed using IBM SPSS Version 20.00. A p-value less than 0.05 is considered as statistically significant. Baseline homogeneity was established using test for linearity. Bivariate analysis was done. The statistical analysis of the data showed that all of the variables except prolonged sitting were normally distributed. Thus correlation was done for prolonged sitting and regression was used for further analysis. Correlation between prolonged sitting and deep abdominal flexor muscle recruitment shows weak negative association with coefficient -0.173. So, there is an association between prolonged sitting

and deep abdominal flexor muscle recruitment and the association is not significant (Sig. value = 0.335 > 0.05). As per Wilcoxon Signed Rank Test rejecting null hypothesis and accepting the alternative hypothesis which means there is an association between deep abdominal flexor muscle recruitment in middle-aged tailors with prolonged sitting. Regression coefficient β value 0.35 which is in between 0.21 and 0.50 indicates weak linear relationship. The positive value of β indicates a direct relation between the dynamic balance and impaired deep abdominal flexor muscle recruitment. As deep abdominal flexor muscle recruitment decreases, there is a proportionate reduction in dynamic balance. The p value < 0.05 shows that it is statistically significant. At 95% confidence interval and degrees of freedom 26 with level of significance 5% table value $t = 2.056$ and calculated value of t statistics value for deep abdominal flexor muscle recruitment and dynamic balance obtained is 25.371 which is greater than table value. Therefore, rejecting the null hypothesis (H_{02}) and accepting the alternative hypothesis (H_{A2}) which means there is relationship between impaired deep abdominal flexor muscle recruitment and dynamic balance in middle-aged tailors.

Regression coefficient β value 0.10 which is in between 0.00 and 0.20 indicates negligible linear relationship. The positive value of β indicates a direct relation between the gait speed and impaired deep abdominal flexor muscle recruitment. As deep abdominal flexor muscle recruitment decreases, there is a proportionate reduction in gait speed. The p value = 0.000 (< 0.05) shows that it is statistically significant. At 95% confidence interval and degrees of freedom 26 with level of significance 5% table value $t = 2.056$ and calculated value of t statistics value for deep abdominal flexor muscle recruitment and gait speed obtained is 8.62 which is greater than table value. Hence, rejecting the null hypothesis (H_{03}) and accepting the alternative hypothesis (H_{A3}) which means there is relationship between impaired deep abdominal flexor muscle recruitment and gait speed in middle-aged tailors. Thus, from the obtained results it can be inferred that there is a significant relationship between impaired deep abdominal flexor muscle recruitment with dynamic balance and gait speed in middle aged tailors.

Table 1: Demographic Representation of Age

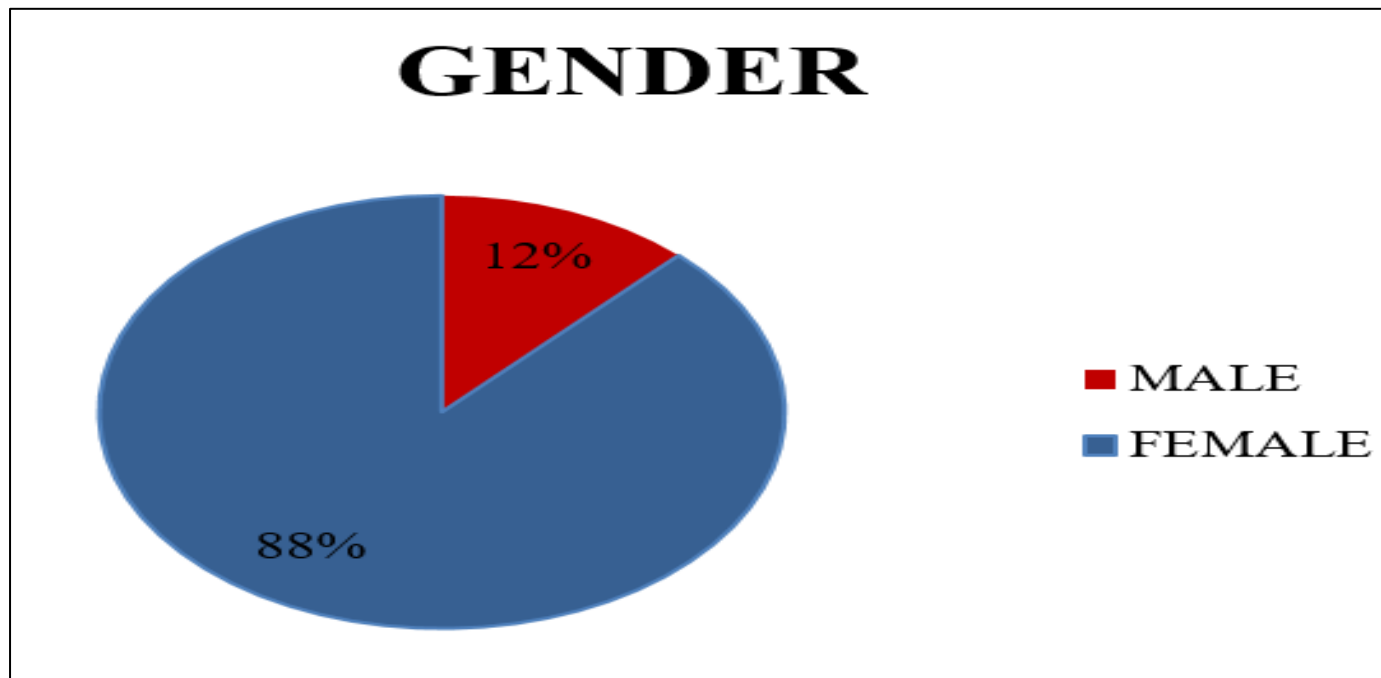
AGE	FREQUENCY	PERCENTAGE
44-48	18	54.54%
49-53	4	12.12%
54-59	11	33.33%
TOTAL	33	100%



Graph 1: Demographic Representation of Age

Table 2: Demographic Representation of Gender

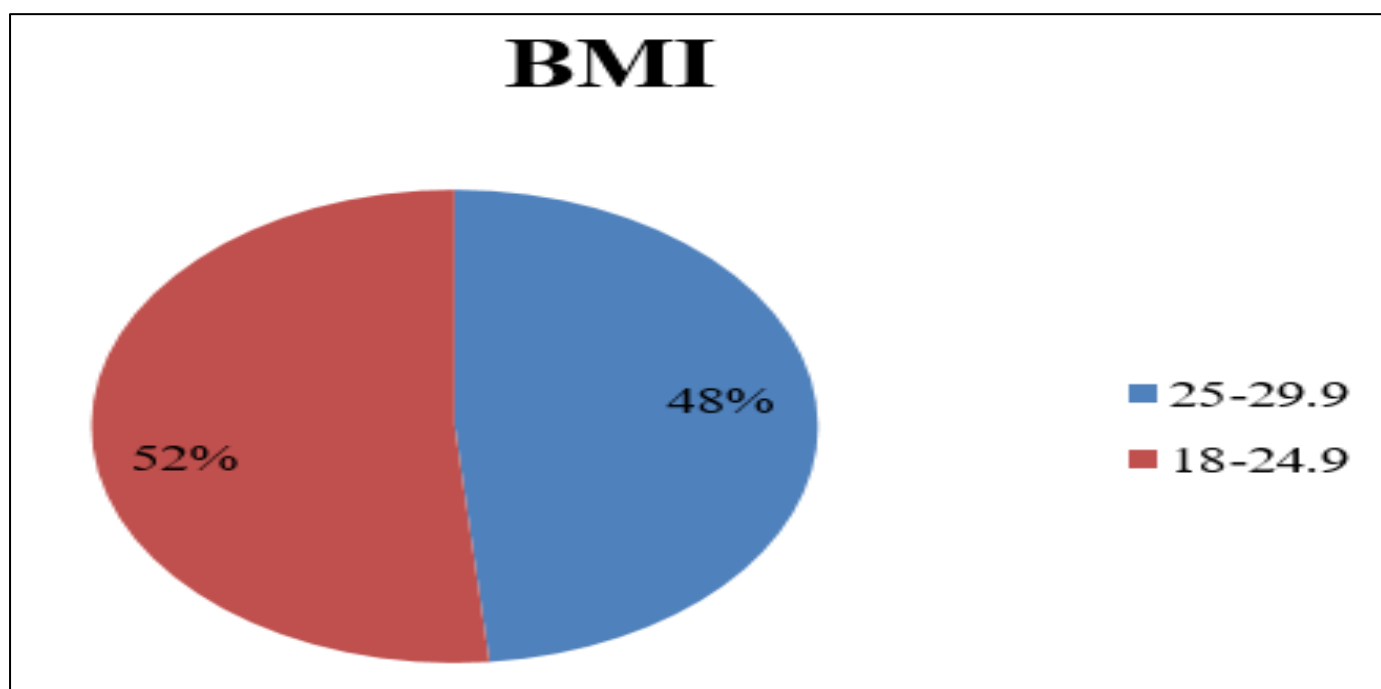
GENDER	FREQUENCY	PERCENTAGE
FEMALE	29	87.87%
MALE	4	12.12%
TOTAL	33	100%



Graph 2: Demographic Representation of Gender

Table 3: Demographic Representation of BMI

BMI CLASS	FREQUENCY	PERCENTAGE
18-24.9	17	51.51%
25-29.9	16	48.48%
TOTAL	33	100%

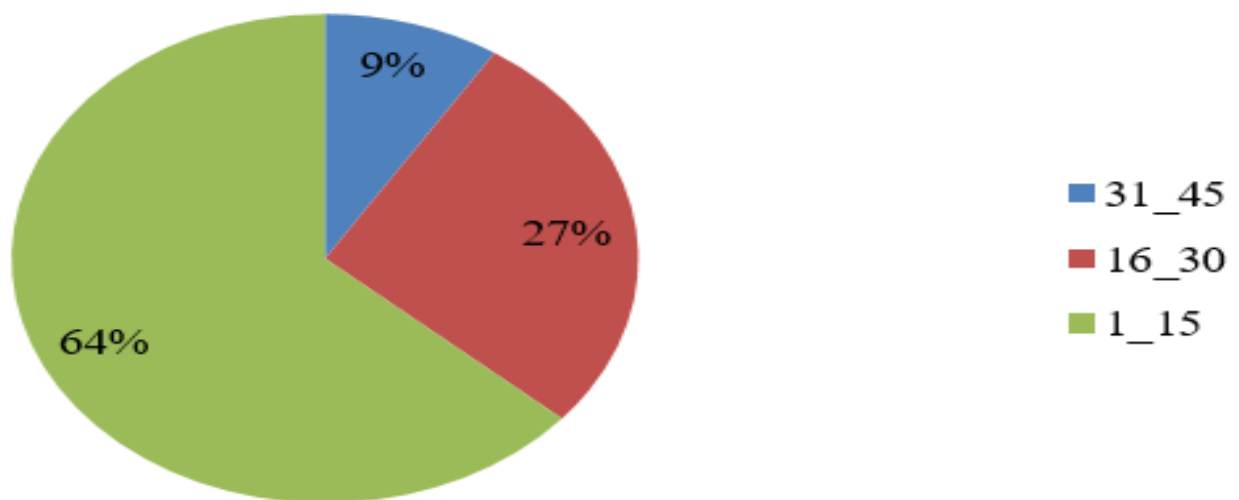


Graph 3: Demographic Representation of BMI

Table 4: Demographic Representation of Years of Working Experience

YEARS OF WORKING EXPERIENCE	FREQUENCY	PERCENTAGE
1-15	21	63.63%
16-30	9	27.27%
31-45	3	9.09%
TOTAL	33	100%

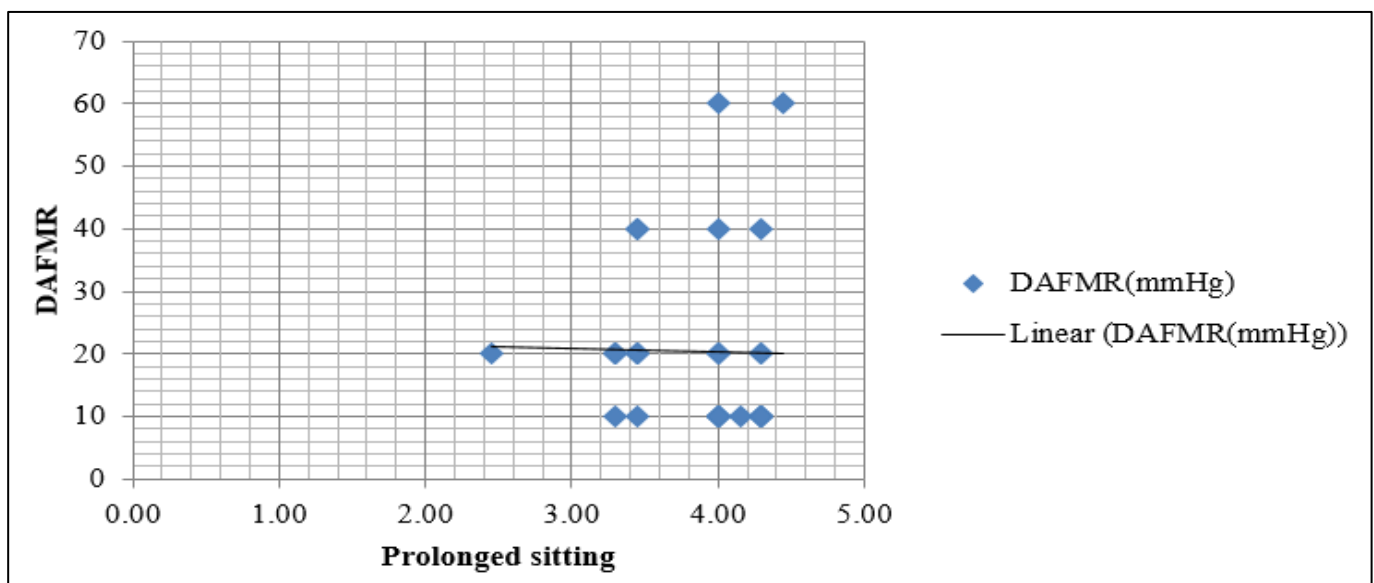
YEARS OF WORKING EXPERIENCE



Graph 4: Demographic Representation of Years of Working Experience

Table 5: Correlation of Deep Abdominal Flexor Muscle Recruitment and Prolonged Sitting

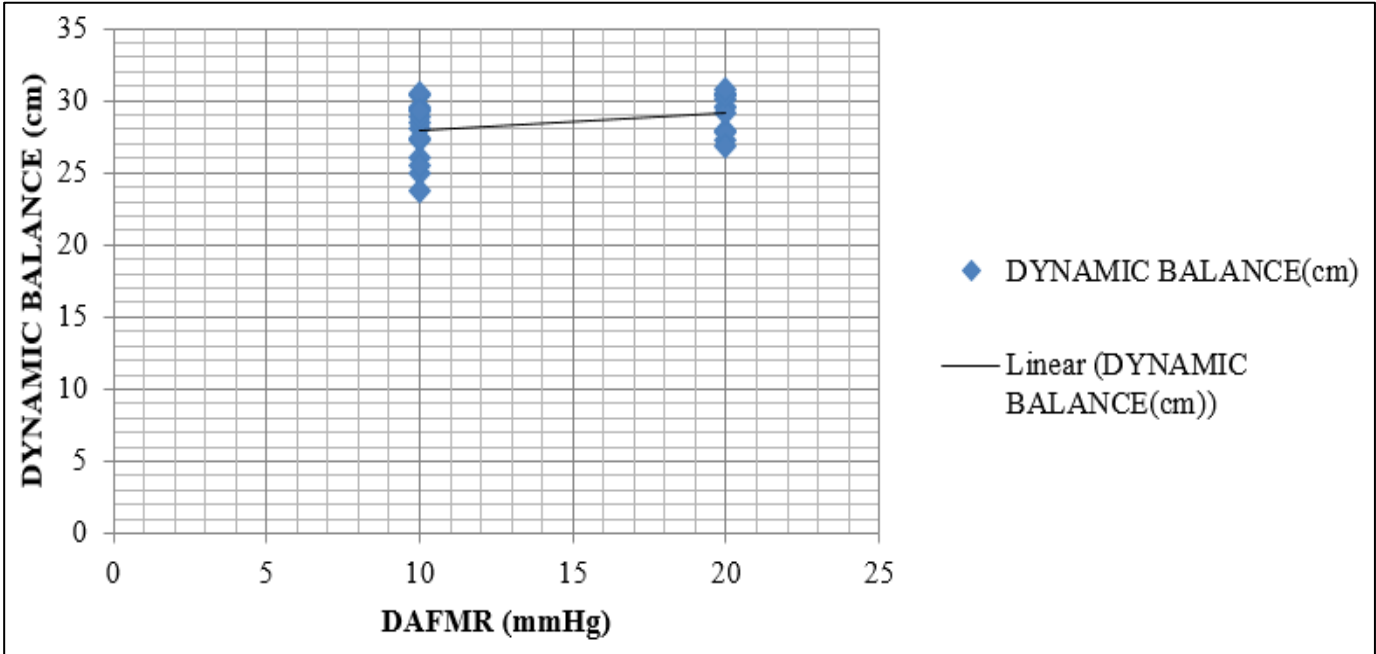
TYPE OF CORRELATION	VARIABLES	COEFFICIENT	N
Spearman's rho	Prolonged sitting (Hr) DAFMR	-0.173	33



Graph 5: Correlation of Deep Abdominal Flexor Muscle Recruitment and Prolonged Stting

Table 6: Regression of Dynamic Balance on Impaired Deep Abdominal Flexor Muscle Recruitment

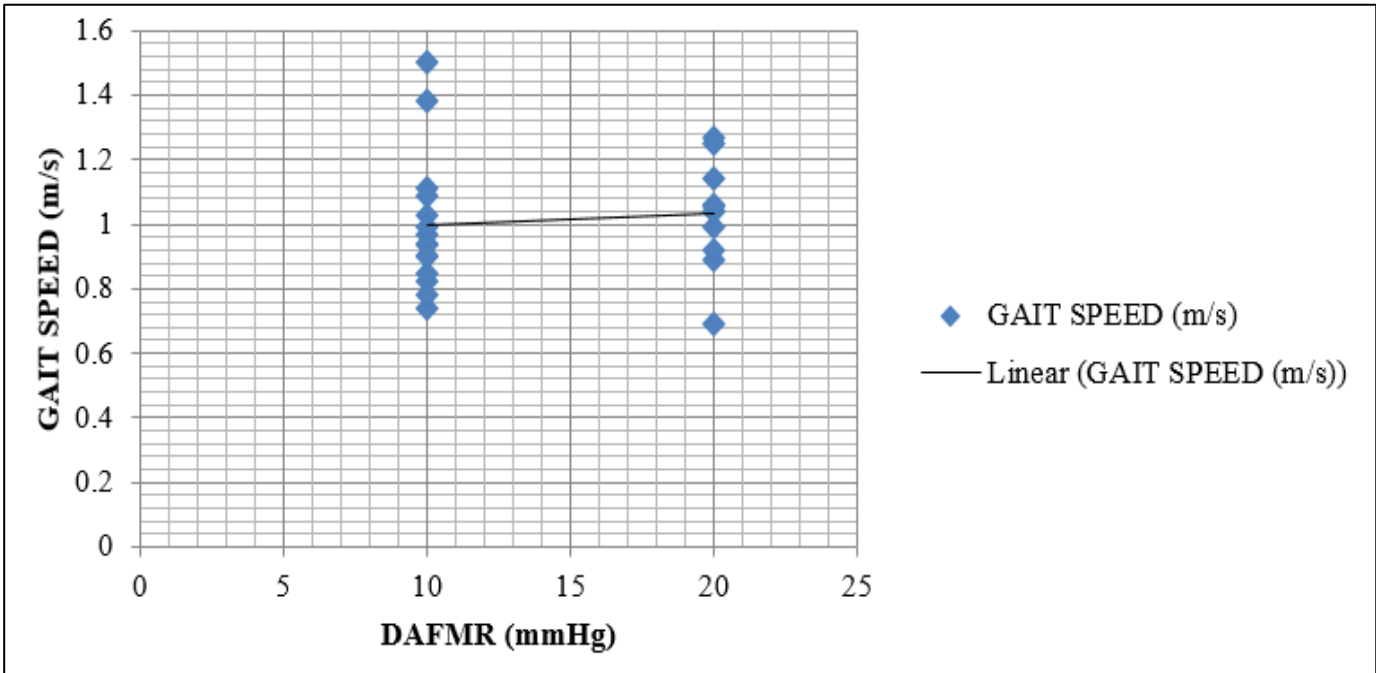
Linear Regression Model	Standardized Coefficients	t	Sig.
	Beta		
Dynamic Balance	0.35	25.37	0.000
DAFMR			



Graph 6: Representation of Relationship Between Dynamic Balance on Impaired Deep Abdominal Flexor Muscle Recruitment

Table 7: Regression of Gait Speed on Deep Abdominal Flexor Muscle Recruitment

Linear regression model	Standardized Coefficients	t	Sig.
	Beta		
Gait speed	0.10	8.62	0.000
DAFMR			



Graph 7: Representation of Relationship Between Gait Speed on Impaired Deep Abdominal Flexor Muscle Recruitment

V. DISCUSSION

The results of the current study showed that there is an association between deep abdominal flexor muscle recruitment and prolonged sitting, and deep abdominal flexor muscle recruitment has a significant linear relationship with dynamic balance and gait speed in middle-aged tailors.

Core muscles such as the lumbo-pelvic, along with hip muscles are located in the centre of the movement chain to produce, transport, and control energy throughout the full functional kinetic chain.¹¹ However, the core serves as a muscular corset that works as a unit to stabilize the body and spine, with and without limb movement i.e. it serves as the centre of the functional kinetic chain. Hence, the core has been referred to as the “powerhouse”, the foundation or engine of all limb movements.¹² Thus, a prolonged decrease in core muscle activity may cause maladaptation in the motor control system and lead to dysfunctions in overall stability along with musculoskeletal disorders.¹¹ As deep muscles of the abdominal wall such as TrA and MF have a key role in the dynamic control of the lumbar spine,⁵ by counterbalancing compressive forces on the upper lumbar segment of the spine to increase lumbar stability.¹³

The TrA is a deep abdominal flexor muscle and its fibers blend into the thoracolumbar fascia and is responsible for increasing intra- abdominal pressure and when contracted produces a 'drawing in' of the abdominal wall.⁵ An association between deep abdominal flexor muscle recruitment and prolonged sitting was found in the current study owing to the fact that sitting posture can affect trunk muscle activity. The local and global muscles of the lumbo-pelvic region can be preferentially facilitated in different sitting postures. In the forward leaning sitting posture, the pelvis tilts forward, and the centre of gravity is in front of the ischial tuberosities. Forward rotation of the pelvis or forward bending of the trunk during sitting significantly increases back muscle activity. Thus, a decrease in trunk muscle efficiency increases the load on the lumbar discs and ligaments resulting in instability.¹⁴

Development of creep phenomena during prolonged sitting can occur after a continuous load, due to collagen matrix disruption and interstitial fluid compression. The induced load can change the mechanical properties of viscoelastic materials, resulting in muscle fatigue. Moreover, there is evidence that creep and prolonged tension may change mechanoreceptor thresholds in viscoelastic paraspinal tissues, which may in turn lead to delayed muscle reflexes.¹¹ Studies have proven that prolonged sitting leads to decrease in activation of TrA muscle, leading to early fatigue and moderate performance index for the TrA strength, thereby resulting in decreased activation of the muscle.⁵ Thus, it can be inferred that deep abdominal flexor muscle recruitment has an association with prolonged sitting.

As per results of the present study, there is a linear relationship between impaired deep abdominal flexor muscle recruitment and dynamic balance. Many factors, such as weak muscle strength, poor balance control, limited range of

motion, slow reaction time, impaired sensory inputs, or neurological disorders, may influence walking ability.¹⁵ Evidence suggests that the main dynamic stabilizer of the lower back and pelvis is the TrA. This may leave the lumbo-pelvic region vulnerable to strain, instability and injury.¹⁴

Stability of the core muscles (abdominals, back extensors, muscles of the proximal lower extremity) is an integral part of all motions of the body. When the body is still, balance is maintained by muscles of the trunk. During movements such as walking, the pelvis undergoes translation through three planes of motion and the core strength determines a person's ability to maintain a stable trunk during motion.¹⁶

Postural control during locomotion also requires the integration of multiple sensory and motor pathways so that the central nervous system can coordinate the postural and movement components of the task.¹⁵ However, the muscles of the local system are continuously activated at low levels, regardless of the body movement.¹⁷ Previous studies have reported that walking quality is closely related to spinal stability, and the TrA is extremely important for spine stabilization.¹⁸ Evidence states that delayed onset of TrA activation leads to inefficient muscular stabilization of the spine and compromised balance.¹⁴ Thus, it may be the reason for impairment in dynamic balance of the middle-aged tailors in the study due to impaired recruitment of the deep abdominal flexor muscle (TrA).

According to results of the study, there also exist a linear relationship between impaired deep abdominal flexor muscle recruitment and gait speed. Trunk coordination has an effect on gait parameters and that flexible adaptations in trunk coordination to changes in walking velocity are considered a hallmark of unaffected gait.¹² With perturbations of neutral spine positions, including arm movements and predictable or unpredictable external trunk loading, muscle activity is automatically adjusted to overcome the spinal perturbation and restore or maintain the spinal orientation.¹⁹ Walking quality is closely related to spinal stability.¹⁷ As feed forward recruitment of the TrA precedes activation of all other muscles during movement of the upper and lower extremities, TrA is important for spine stabilization and anticipatory postural control.^{10,20} A weaker TrA due to absence of feed forward recruitment mechanism might result in a lower gait speed and may contribute to an inactive life and further weakening of the muscle strength and a high risk of falling.¹⁰

Moreover, gait speed is highly correlated to dynamic stability. Both gait speed and step length is important factors that can affect dynamic stability. A slower gait speed predisposes a person to high risk of backward balance loss due to weak TrA. If the step length is shorter, it can mitigate the risk of falling backward, as a shorter step length shifts the COM closer to the BOS at the toe off.²¹ Thus, the decreased gait speed owing to a weaker deep abdominal flexor muscle recruitment in the middle-aged tailors might affect the dynamic stability too.

The findings of this study implies that there is a relationship between deep abdominal flexor muscle recruitment with dynamic balance and gait speed in middle aged tailors.

➤ Limitations

- Equal gender distribution was not obtained.
- Difficulty for data collection was experienced due to limited space in tailoring units.

➤ Suggestion for Future Studies

- Future studies can be conducted by categorise the subjects according to the type of delivery, gender and by comparing deep abdominal flexor muscle recruitment in professional and recreational tailors.
- Future study can be done on tailors using interventions like deep abdominal flexor muscle activation exercises.

VI. CONCLUSION

This study aimed to estimate the deep abdominal flexor muscle recruitment and its relationship between with dynamic balance and gait speed in middle-aged tailors. The study reveals that there is an association between deep abdominal flexor muscle recruitment and prolonged sitting, and also there exist a linear relationship between impaired deep abdominal flexor muscle recruitment with dynamic balance and gait speed. Thus, the study concluded that there is influence of impaired deep abdominal flexor muscle recruitment on dynamic balance and gait speed in middle-aged tailors. The study suggests that tailors can be provided rest breaks in between prolonged sitting sessions to prevent the musculoskeletal discomfort which has the potential to affect the dynamic balance and gait speed too.

LIST OF ABBREVIATIONS

- 4MGS: 4 Meter Gait Speed
- BOS: Base Of Support
- COM: Center Of Mass
- DAFMR: Deep abdominal flexor muscle Recruitment
- FRT: Functional Reach Test
- GPAQ: Global Physical Activity Questionnaire
- MF: Multifidus
- PBU: Pressure Biofeedback Unit
- TrA: Transversus Abdominis

AUTHOR CONTRIBUTIONS

The author's confirm contribution to the paper as follows: Study conception and Design: Jesmi John A and Chinchu Alwin; Data Collection: Jesmi John A; Review and Editing: Anumol C and Rakhi Balagopal; Analysis and Interpretation: Jesmi John A, Remya N, Manju Unnikrishnan and Rejimol Jos Pulicken; Draft manuscript: Jesmi John A, Chinchu Alwin and Reeba Roy. All the authors reviewed the results and approved the final version of the manuscript.

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- **Ethical Approval:** Approved

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