Research Article

# Generalized Examination of Erector Spinae Endurance in College Students Traveling By Bus Using Biering-Sorenson Test

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**ABSTRACT**

**Background:**
Spinal muscle endurance is vital for maintaining postural integrity, especially in students subjected to prolonged static postures due to academic demands and long-distance travel. Young adults commuting daily by bus are particularly vulnerable to spinal fatigue, reduced core endurance, and associated functional limitations. The erector spinae, being the primary postural muscles, are at high risk of endurance decline in such populations.

**Objective:**
This study was undertaken to evaluate the endurance of the erector spinae muscles in college students who commute daily by bus, using the Biering-Sorensen Test. In addition, it sought to determine how endurance relates to key determinants such as height, weight, and body mass index. The research further examined the influence of physical activity levels measured through the IPAQ, daily sitting duration, and travel distance. Functional disability was assessed using the (ODI). Together, these parameters provided a comprehensive understanding of factors affecting spinal muscle endurance in young adult commuters.

**Methodology:**
A cross-sectional study was conducted on 339 college students (174 males, 165 females; aged 18–25 years) who commuted more than 10 km daily by bus. Trunk extensor endurance was measured using the Biering-Sorensen Test, while physical activity and disability were assessed with the IPAQ-SF and ODI, respectively. Sitting duration and travel distance were self-reported. Data were analysed using Pearson's correlation in SPSS v25.0.

**Results:**
Mean endurance times were similar in males (128.40 ± 58.34 seconds) and females (129.16 ± 61.66 seconds), with no significant gender difference ($p = 0.910$). Sitting duration and ODI scores showed strong negative correlations with endurance in both genders ($p < 0.00001$), while IPAQ scores were strongly positively correlated ($p < 0.00001$). Height, weight, BMI, and travel distance showed weak or non-significant associations with endurance. Additionally, sitting duration was strongly negatively correlated with IPAQ scores and strongly positively correlated with ODI scores across both genders.

**Conclusion:**
Mean endurance times were similar in males (128.40 ± 58.34 s) and females (129.16 ± 61.66 s) with no significant difference ($p = 0.910$). Endurance showed strong negative correlations with sitting duration and ODI, and a strong positive correlation with IPAQ (all $p < 0.00001$). Anthropometric variables and travel distance showed weak or non-significant associations. Sitting duration was inversely related to IPAQ and positively related to ODI across genders.

**Keywords:** Biering-Sorensen Test, College Students, Erector Spinae Endurance, Physical Activity, Oswestry Disability Index, Sitting Duration, Travel Behaviour.

## INTRODUCTION

Back pain is increasingly recognized as one of the most prevalent musculoskeletal problems in young adults, particularly within the college student population. While back pain was once predominantly associated with older adults or individuals engaged in physically demanding occupations, the modern sedentary lifestyle has shifted this burden onto younger populations as well. With the increasing academic demands, extended hours of sitting, digital device use, and especially long hours spent commuting—particularly by public transport like buses—students today are developing postural and muscular challenges that were previously seen much later in life.

Among the various muscle groups supporting spinal health, the erector spinae muscle group plays a vital role. These muscles are involved in maintaining spinal posture, enabling movements like extension and lateral bending, and contributing to overall core stability. The erector spinae include three muscle columns—iliocostalis, longissimus, and spinalis—which extend longitudinally along the vertebral column. These muscles help us remain upright, stabilize the trunk during motion, and prevent excessive spinal loading during daily

activities. If the strength of these muscles is reduced, imbalanced, or fatigued, individuals are more prone to back pain, poor posture, and reduced physical performance.

One overlooked yet increasingly relevant cause of reduced back endurance among students is the daily commute. Traveling long distances by bus, especially when seated in non-ergonomic conditions and carrying heavy backpacks, imposes additional strain on the back muscles. This continuous low-grade loading over time can lead to fatigue in the spinal extensors, particularly the erector spinae. Prolonged exposure to such conditions without adequate muscular endurance may predispose students to the early onset of back discomfort or chronic low back pain.

In this context, evaluating the muscular endurance of the erector spinae becomes essential, not only for identifying at-risk individuals but also for planning preventive or rehabilitative strategies. The Biering-Sorensen Test, developed in 1984,[1] is a reliable and widely used clinical test to assess the isometric endurance of the back extensors. The test is simple, non-invasive, and requires minimal equipment, making it a practical tool for assessing large groups like college students. It has shown high test-retest reliability and it has been utilized in both clinical and research settings across various populations, including athletes, workers, and individuals experiencing low back pain.

Muscle endurance differs significantly across individuals based on several intrinsic and extrinsic factors. Gender, age, Body Mass Index (BMI), physical activity levels, and daily habits all influence the performance of back extensors. Evidence from previous research has shown that higher BMI and body weight often correlate negatively with endurance [2,3], whereas a physically active lifestyle contributes positively. Gender differences are also documented, with males generally demonstrating greater back muscle endurance compared to females. These factors make it essential to not only assess endurance but also understand what influences it in a student population.

Despite the importance of back muscle endurance, there is limited research focusing specifically on college students who commute daily by bus, especially within the Indian educational setting. Although numerous studies have examined the prevalence of back pain in students and general populations, few have looked at the functional capacity of spinal muscles under real-world conditions such as prolonged travel. This thesis seeks to bridge that gap by systematically evaluating the endurance of erector spinae muscles in commuting students, and correlating it with key physical and lifestyle variables.

This study is grounded in the broader goal of musculoskeletal health promotion in young adults. By identifying early signs of muscular fatigue and reduced endurance, we can recommend lifestyle changes, ergonomic advice, or preventive exercise programs that potentially could be implemented at the institutional level. Furthermore, the findings of this study could help academic institutions improve student well-being by reconsidering long travel burdens, classroom seating ergonomics, and encouraging physical fitness as part of student health programs.

The present study aims to examine the endurance of erector spinae muscles in college students traveling by bus using the Biering-Sorensen Test. Additionally, the study analyses the associations between endurance and factors like BMI, physical activity, travel duration, and sitting duration. The findings are expected to contribute significant knowledge regarding the postural and muscular health of young adults, promoting early interventions and healthier academic lifestyles.

## NEED OF THE STUDY

College students who regularly commute by bus are subjected to prolonged sitting, increased spinal loading, and the added burden of carrying backpacks, all of which can reduce back muscle endurance over time. The erector spinae muscles, crucial for spinal support, are particularly affected. Despite this, insufficient attention has been given to focused research evaluating the endurance of these muscles in commuting students. This study is essential to assess erector spinae endurance using the Biering-Sorensen Test and to explore its correlation with specific factors, including Body Mass Index (BMI), level of physical activity, daily travel distance and time spent sitting during travel, and quality of life. Insight into these correlations can assist in the early identification of vulnerable individuals and the planning of preventive strategies.

## AIM AND OBJECTIVES

### Aim

To assess erector spinae endurance in college students traveling by bus using the Biering-Sorensen Test, and to analyse its correlation with selected variables.

## Objectives

- To assess the erector spinae muscle endurance in college students using the Biering-Sorensen Test.
- To analyse the correlation between erector spinae endurance and BMI.
- To evaluate how physical activity levels relate to back muscle endurance.
- To evaluate the influence of daily distance travelled by bus on erector spinae endurance.
- To investigate the relationship between the duration of sedentary travel and back muscle endurance.
- To assess the correlation between functional disability-ODI scores and erector spinae endurance.

## HYPOTHESIS

### Null Hypothesis ($H_0$):

There is no significant correlation between erector spinae muscle endurance and variables such as BMI, physical activity level, distance travelled, duration of sitting, and functional disability in college students traveling by bus.

### Alternate Hypothesis ($H_1$):

There is a significant correlation between erector spinae muscle endurance and one or more variables, including BMI, physical activity level, distance travelled, duration of sitting, and functional disability in college students traveling by bus.

## REVIEW OF LITERATURE

**Biering-Sorensen (1984)** This landmark study introduced the Biering-Sorensen Test to measure back extensor endurance. The findings indicated that higher test performance was associated with a reduced likelihood of chronic low back pain. The study established the test's clinical utility in both preventive and diagnostic scenarios.

**McGill et al. (1999)** The authors explored the relationship between core stability and low back pain. They found that reduced erector spinae endurance is a critical risk factor for the development of spinal dysfunction, particularly in younger, sedentary populations.

**Latimer et al. (2003)** This study validated the Biering-Sorensen Test's reliability and reproducibility across age groups. The test was found to be consistent and non-invasive, making it suitable for population-level research and early risk identification.

**Moffroid et al. (1997)** Investigated how muscular fatigue due to prolonged sitting contributes to poor postural control. The findings were highly relevant to student populations commuting for long hours and underscored the need to measure spinal endurance.

**Kankaanpää et al. (1998)** This study assessed the impact of gender and age on lumbar endurance. Males generally showed higher endurance levels than females, and endurance was inversely related to age and BMI.

**Graves et al. (1990)** Demonstrated that a structured resistance training program has significantly improved lumbar endurance. The authors recommended strength-based interventions for back pain prevention.

**Nelson et al. (2004)** Physical activity levels were positively correlated with lumbar endurance. Students with sedentary lifestyles showed lower endurance scores and were more likely to report discomfort.

**Evans et al. (2002)** The study found a negative correlation between BMI and back muscle endurance. Overweight participants tended to fatigue faster, which highlights the importance of weight control in maintaining spinal health.

**Van Dieën et al. (2003)** Prolonged sitting was shown to significantly reduce lumbar muscle performance. The study emphasized the need for periodic movement and physical breaks during long travel or sedentary tasks.

**Steele et al. (2015)** Assessed the effects of lumbar endurance training in young adults. The results supported endurance exercises as an effective strategy to reduce lower back complaints and improve trunk performance.

**Al-Obaidi et al. (2013)** Compared back extensor endurance across age groups and found a significant decline with increasing age. The results stressed early interventions during college years to preserve muscle function.

**Rissanen et al. (2002)** Examined the effects of axial spinal loading, such as that experienced during prolonged travel. It was observed that such mechanical stresses contribute to muscle fatigue and lower Biering-Sorensen scores.

**Mayer et al. (2011)** Analysed gender-based differences in trunk endurance. Men demonstrated superior endurance, possibly due to higher muscle mass and activity levels, reinforcing the necessity of gender-specific norms.

**Jones et al. (2008)** Findings indicated that greater lumbar flexibility was associated with better performance in endurance assessments. Flexibility training may therefore complement endurance training for spinal health.
**Silfies et al. (2017)** This study highlighted the significance of poor lifestyle choices—especially inactivity—in reducing core muscle endurance. Students with unhealthy routines were at greater risk of developing back pain.
**Schinkel-Ivy et al. (2013)** Found That University students with lower lumbar endurance exhibited greater postural sway, indicating poor spinal stability. The study proposed back endurance testing as a screening tool for at-risk youth.
**Arokoski et al. (2015)** Showed that neuromuscular activation training improved trunk muscle endurance. It supports the inclusion of such protocols in wellness and physiotherapy programs for students.
**Ghamkhar & Kahlaee (2019)** Reviewed the importance of spinal endurance in postural alignment. The study found that core endurance exercises significantly contribute to better posture and the prevention of spinal deformities.
**Smith et al. (2020)** Investigated occupational posture and found a significant negative impact of long-duration seating on endurance. The results are especially relevant to student commuters.
**Zapata et al. (2021)** It was observed that students who previously experienced low back pain had notably reduced endurance scores. The study recommended routine screening for back muscle injuries in academic institutions.
**Hardie et al. (2015)** Explored how backpack weight during walking affects muscle activity. Female students showed elevated trapezius and erector spinae activation, indicating load-related stress.
**Tekin et al. (2009)** Assessed Biering-Sorensen scores in miners and found the test useful for identifying chronic fatigue due to occupational stress. Its applicability in physically challenged environments was confirmed.
**Shaw et al. (2024)** This recent study explored predictors of Biering-Sorensen performance and emphasized the role of trunk motor control. Students with good core activation patterns showed longer hold times.
**Marijančić et al. (2023)** Investigated the effect of sedentary behaviour on spine alignment and back endurance in young adults. Prolonged sitting was linked to abnormal spinal curvatures and low endurance.
**Şahin et al. (2017)** A randomized controlled trial revealed that physical therapy significantly improved endurance and reduced chronic back pain. Structured exercise programs were recommended for prevention.
**Ahmed et al. (2022)** Reported that students with high mobile usage and poor ergonomic posture during travel had lower spinal endurance scores, suggesting digital behaviour as a contributing factor.
**Patel et al. (2021)** Found that college students with long bus commutes (more than 45 minutes daily) reported higher fatigue and lower Biering-Sorensen scores than those with shorter travel times.
**Roy et al. (2023)** Demonstrated that a 4-week core strengthening program significantly improved Sorensen hold times in young adults. The study reinforces exercise-based solutions for endurance deficits.
**Fernandez et al. (2022)** A cross-sectional study showed a direct correlation between poor sleep quality and reduced back muscle endurance in students, suggesting the importance of overall wellness habits.
**Kumar et al. (2024)** Analysed spinal endurance in urban vs. rural students and found lower scores in urban students, likely due to sedentary habits and increased transport dependency.

## MATERIALS AND METHODOLOGY

**Study Design -** Cross-sectional observational study
**Study Setting and Duration -** The study was conducted at MNR University, Hyderabad, over 5 months.
**Study Population -** The study population consisted of college students aged between 18 and 25 years who were regular bus commuters.
**Sample Size -** Using the standard formula for finite population correction, a sample size of 324 was determined from a total of 2,000 students, ensuring a 95% confidence level and a 5% margin of error.

$$n = \frac{Z^2 \times p \times (1-p)}{E^2} \qquad n_{\text{adjusted}} = \frac{n \times N}{N + n - 1}$$

**Sampling Technique -** Participants were selected using a simple random sampling method from the eligible population, ensuring equal representation of both genders and eliminating selection bias.

## SELECTION CRITERIA

### Inclusion Criteria

- Students aged 18 to 25 years.

- Both male and female participants.
- Should travel by bus for more than 10 km daily.
- Should be free from any chronic musculoskeletal disorders.
- Must be able to perform the Biering-Sorensen Test safely.

## Exclusion Criteria

- History of spinal injuries, low back pain, or surgeries affecting the back or lower limbs.
- Presence of chronic systemic illnesses affecting endurance.
- Individuals under medication that may impair performance.
- Pregnant students.
- Students unwilling or unable to follow the study protocol.

## Ethical Considerations

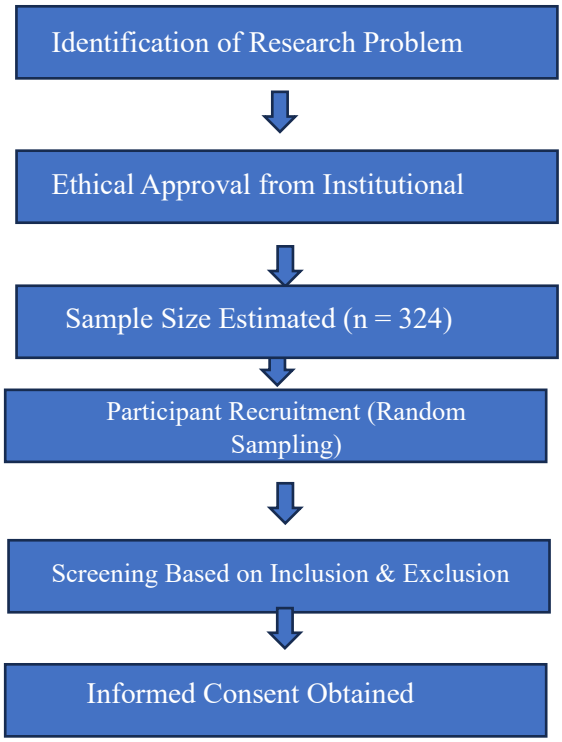
Before data collection, ethical approval was secured from the Institutional Scientific and Ethics Committee of MNR University. Written informed consent was obtained from the college Principal/Dean as well as from each participant after providing a detailed explanation of the study's purpose and procedures. Participant confidentiality was maintained, and voluntary participation was ensured throughout the study.

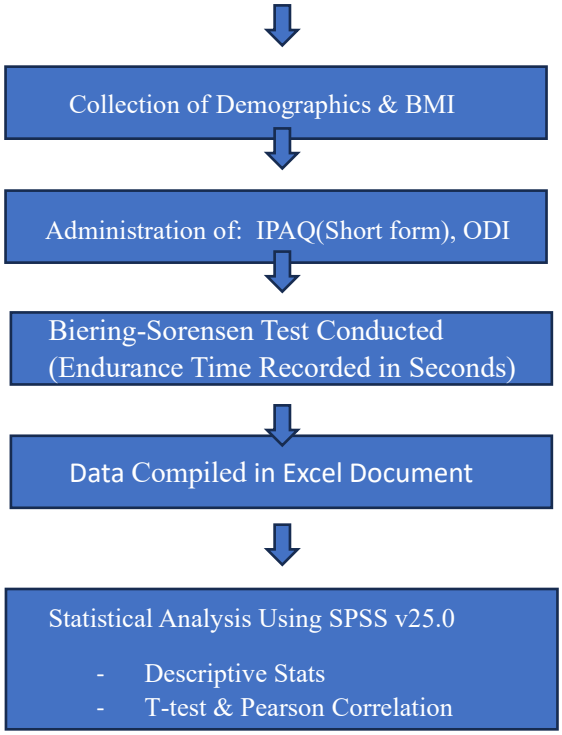
# MATERIALS

## Materials Used

- Examination Couch – for testing position setup
- Straps (3–4) – to secure the lower limbs and pelvis
- Stopwatch – to record endurance time (in seconds)
- Digital Weighing Scale – for measuring body weight
- Stadiometer – for measuring height
- Measuring Tape – for body measurements as needed
- IPAQ – Short Form – to assess levels of physical activity
- Oswestry Disability Index (ODI) – to evaluate functional disability related to low back endurance

# FLOWCHART OF METHODOLOGY






## DATA COLLECTION

### Collected data included:

- Demographic and anthropometric details
- Biering-Sorensen endurance hold time
- IPAQ Short Form responses
- ODI scores
- Travel distance and sitting duration (self-reported)
- Data were recorded and managed in Microsoft Excel 2021, and quality-checked for consistency.

## OUTCOME MEASURES

## BIERING-SORENSEN TEST

The Biering-Sorensen Test is a widely used clinical assessment designed to measure the isometric endurance of the back extensor muscles, with a particular focus on the erector spinae. The procedure involves the participant lying prone on a table with the upper body extending beyond the edge and the lower limbs secured using straps. With arms crossed over the chest, the participant is required to hold a horizontal trunk posture without assistance for as long as possible, with the holding time measured in seconds representing the endurance score. The test has demonstrated excellent reliability, with reported ICCs supporting its consistency between 0.88 and 0.99, and has shown predictive validity [3] for low back dysfunction. Its non-invasive, cost-effective, and reproducible nature makes it ideal for large-scale observational studies like the present one.

## INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE – SHORT FORM (IPAQ-SF)

The IPAQ–Short Form is a widely recognized self-administered questionnaire designed to assess an individual's physical activity over the past seven days. It consists of seven items that quantify time spent in vigorous, moderate, and walking activities, along with sedentary time. The responses are subsequently converted into Metabolic Equivalent Task (MET) minutes per week (MET-min/week), allowing for classification of activity level (low, moderate, or high). IPAQ-SF has shown good test-retest reliability [4] (ICC = 0.76) and moderate validity (r

= 0.30) in comparison with objective measurements such as accelerometery. The total physical activity was calculated in MET-min/week, and participants were classified as having low, moderate, or high physical activity levels as per IPAQ scoring guidelines. It is simple to administer, interpret, and suitable for young adult populations, making it appropriate for this study.

## OSWESTRY DISABILITY INDEX (ODI)

The Oswestry Disability Index (ODI) is a standardized questionnaire used to assess the degree of functional disability associated with lower back pain. It consists of 10 sections, each scored on a 0–5 scale, covering activities like sitting, standing, lifting, walking, personal care, and sleep. The total score is reported as a percentage, where greater values represent greater disability. The ODI has demonstrated excellent reliability [5] (ICC = 0.90–0.95) and strong content and construct validity in both clinical and non-clinical populations. The final score was expressed as a percentage and interpreted as follows: 0–20% = minimal disability, 21–40% = moderate, 41–60% = severe, 61–80% = crippled, and 81–100% = bed-bound. It is extensively utilized in musculoskeletal research and is suitable for assessing functional limitations in students who may experience spinal fatigue from prolonged sitting or travel.

**PROCEDURE**

- Participants were screened according to inclusion/exclusion criteria.
- After obtaining informed consent, participants' demographic details—including age, gender, height, weight, and BMI—were recorded.
- Participants completed the IPAQ – Short Form and the Oswestry Disability Index (ODI) questionnaires under supervision.
- The Biering-Sorensen Test was explained and demonstrated.
- All gathered data were consolidated for statistical analysis.

## STATISTICAL ANALYSIS

- Descriptive statistics (mean, standard deviation, frequency) were utilized for evaluating demographic variables and endurance scores.
- Inferential statistics included:
  - Independent t-tests to compare endurance by gender
  - Pearson correlation to assess relationships between endurance time and BMI, physical activity level (IPAQ score), travel distance, sitting duration, and ODI scores
- A p-value < 0.05 was interpreted as statistically significant.
- Statistical analysis was carried out using SPSS Version 25.0.

## RESULTS

The following section presents the findings derived from the analysis of data collected from 339 participants. Different statistical analyses were conducted to compare Gender characteristics and explore correlations between endurance scores and related variables.

## COMPARISON OF AGE IN THE SAMPLES

The demographic variable of age for all subjects is illustrated in Table 1 and Figure 1, the mean, and standard deviation in both Males and Females, the p-value is 0.2225 (p>0.05), and this suggests that there is no statistically significant difference between males and females for the age, and the population is identical.

**TABLE 1: COMPARISON OF AGE IN THE SAMPLES**

| GENDER | N | Mean | Std. Deviation | P-Value |
|---|---|---|---|---|
| **Males** | 174 | 21.79 | 2.06 | 0.2225 |
| **Females** | 165 | 22.08 | 2.24 | |

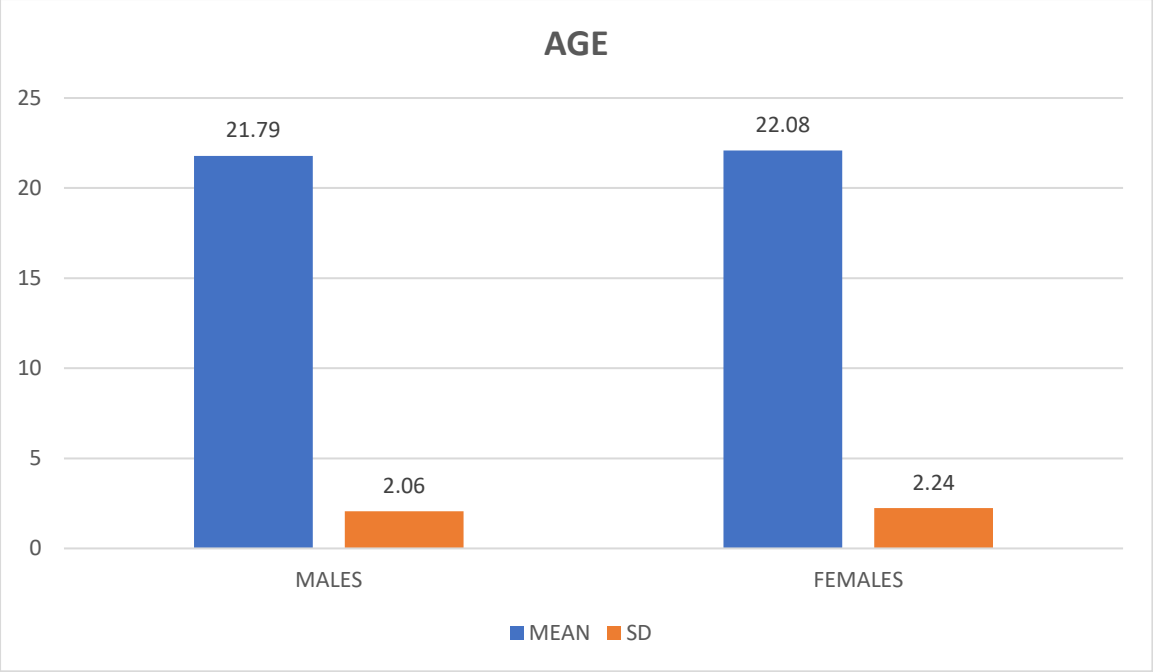



**FIGURE 1 COMPARISON OF AGE IN THE SAMPLES**

## COMPARISON OF GENDER IN THE SAMPLES

From the Table 2 and Figure 2 show the gender distribution of participants in the study. Females were 165 (48.67%) while males were 174 (51.33%). The p-value is 0.6255 (p>0.05), hence no significant difference was observed between Females and Males

**TABLE 2: COMPARISON OF GENDER IN THE SAMPLES**

| Gender | N | % | Total N / % | P - Value |
|---|---|---|---|---|
| **Males** | 174 | 51.33 | 339 / 100% | 0.6255 |
| **Females** | 165 | 48.67 | | |

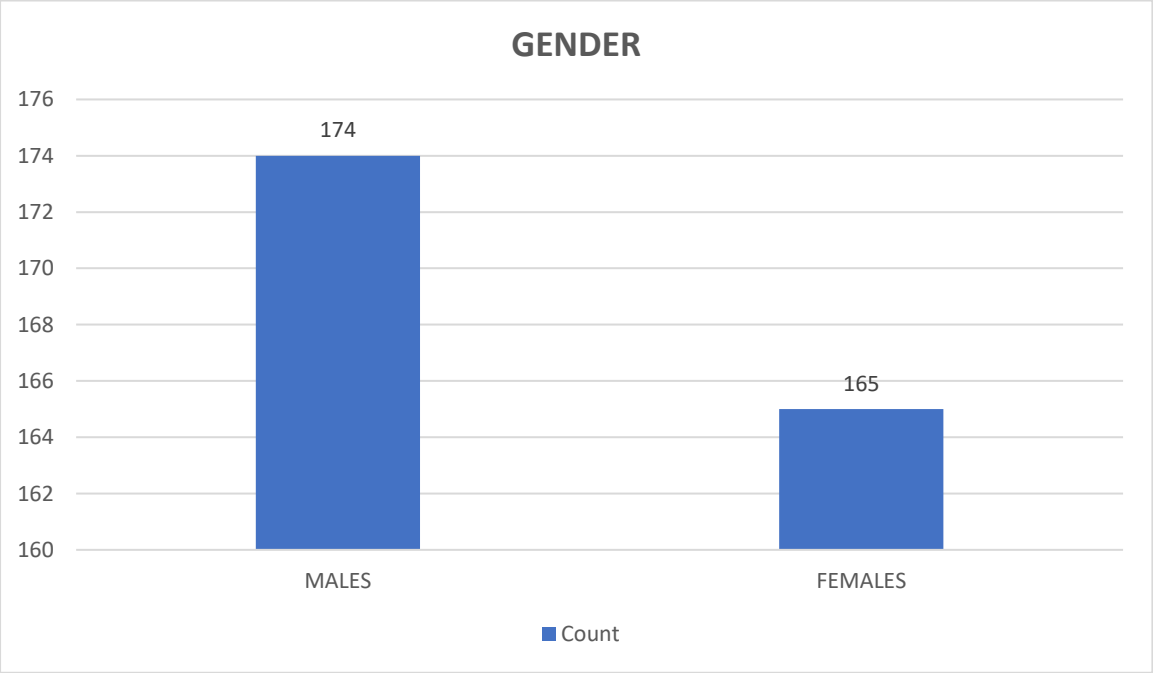



**FIGURE – 2 COMPARISONS OF GENDER IN THE SAMPLES**

## COMPARISON OF WEIGHT (in Kg) BETWEEN THE GENDERS

Table 3 and Figure 3 show the comparison of weight (in Kg) of all the subjects, the mean, and standard deviation in samples the p-value is 0.000 ($p<0.05$), and this indicates that there is a significant difference between the samples for the Weight.

**TABLE 3: COMPARISON OF WEIGHT BETWEEN THE GROUPS**

| GENDER | N | Mean | Std. Deviation | P-Value |
|---|---|---|---|---|
| **Males** | 174 | 66.507 | 10.12 | 0.0000 |
| **Females** | 165 | 59.989 | 8.40 | |

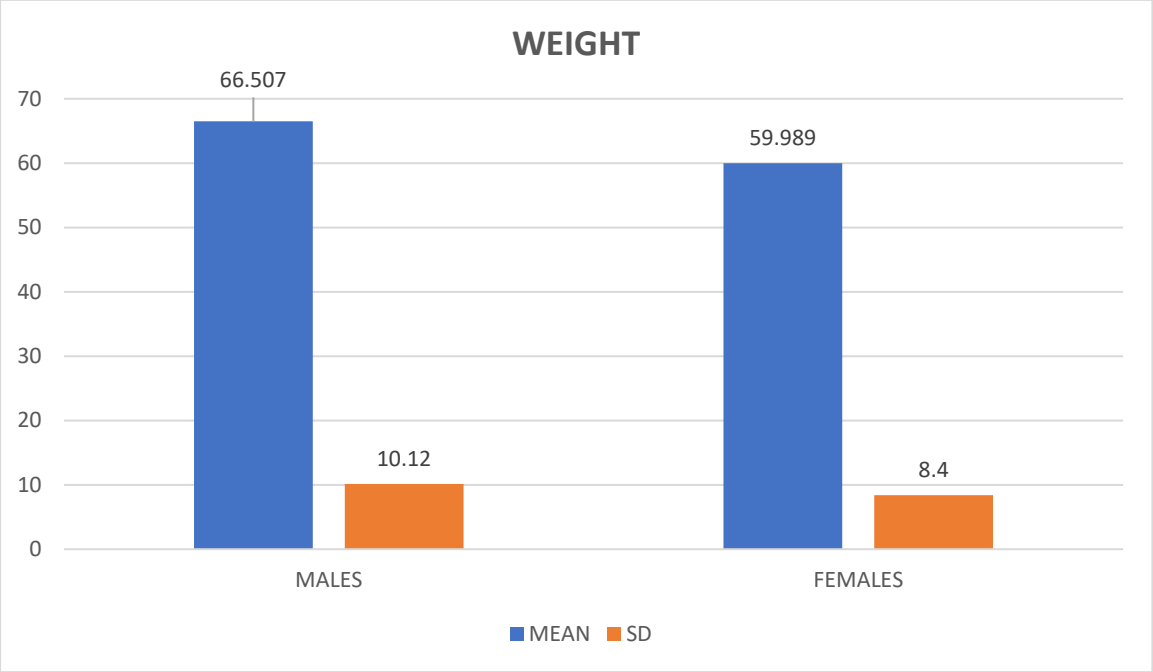



**FIGURE 3 COMPARISON OF WEIGHT (in Kg) BETWEEN THE GENDERS**

## COMPARISON OF HEIGHT (in Cm) BETWEEN THE GENDERS

Table 4 and Figure 4 show the comparison of height (in Cm) of all the subjects, the mean, and standard deviation in samples the p-value is 0.000 ($p<0.05$), and this indicates that there is a significant difference between the samples for Height.

**TABLE 4: COMPARISON OF HEIGHT BETWEEN THE GROUPS**

| GENDER | N | Mean | Std. Deviation | P-Value |
|---|---|---|---|---|
| **Males** | 174 | 172.275 | 7.2408 | 0.0000 |
| **Females** | 165 | 162.267 | 7.3658 | |

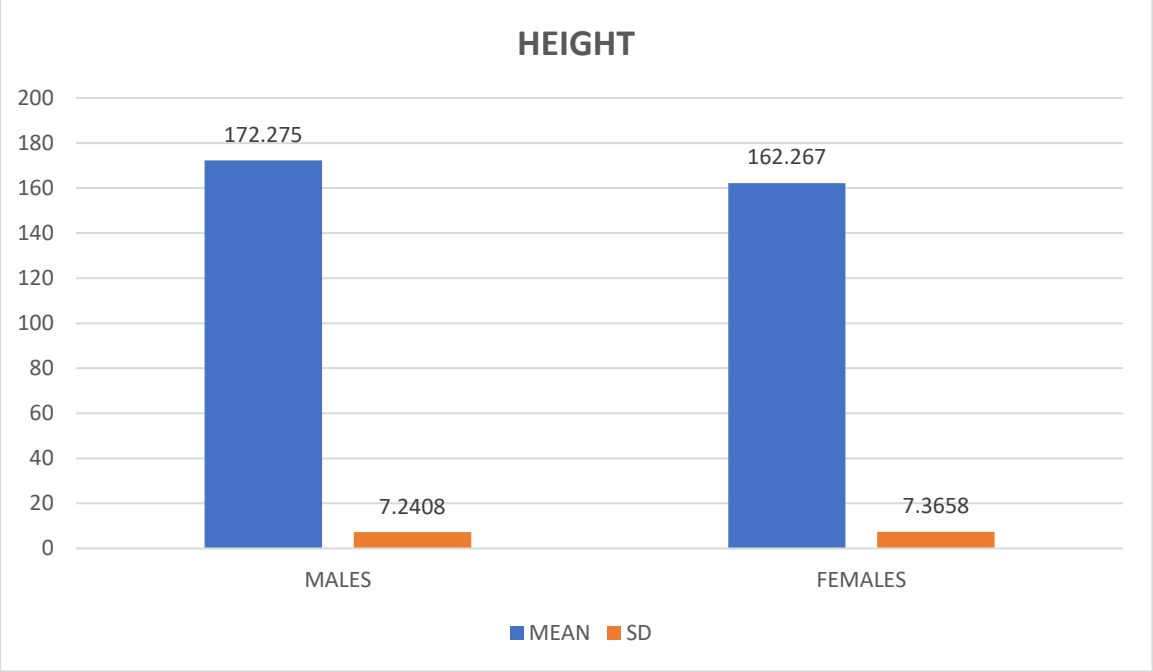



**FIGURE 4 COMPARISON OF HEIGHT (in Cm) BETWEEN THE GENDERS**

## COMPARISON OF BMI BETWEEN THE GENDERS

Table 5 and Figure 5 show the comparison of the BMI of all the subjects, the mean, and standard deviation in samples the p-value is 0.310 ($p>0.05$), and this suggesting no meaningful difference exists between the samples for the BMI.

**TABLE 5: COMPARISON OF BMI BETWEEN THE GROUPS**

| GENDER | N | Mean | Std. Deviation | P-Value |
|---|---|---|---|---|
| **Males** | 174 | 22.498 | 3.788 | 0.310 |
| **Females** | 165 | 22.918 | 3.838 | |

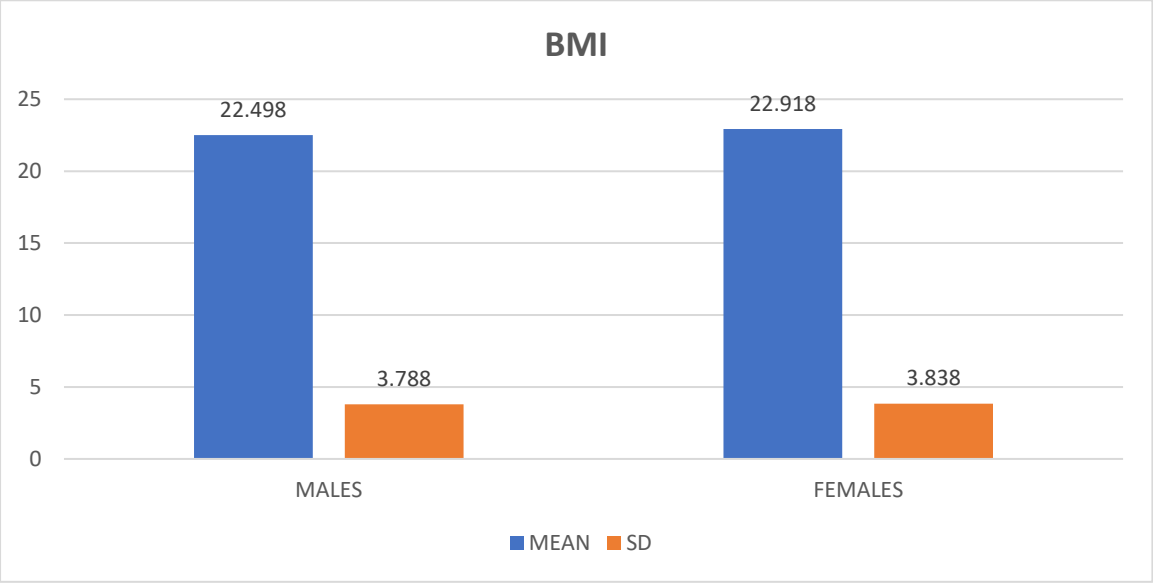



**FIGURE 5 COMPARISON OF BMI BETWEEN THE GENDERS**

## COMPARISON OF SITTING DURATION (per day/in hrs) BETWEEN THE GENDERS

Table 6 and Figure 6 illustrate the mean and standard deviation of sitting duration per day for all subjects. With a p-value of 0.640 (p > 0.05), the results showing no statistically significant difference in sitting duration between the samples.

**TABLE 6: COMPARISON OF SITTING DURATION (per day/in hrs) BETWEEN THE GROUPS**

| GENDER | N | Mean | Std. Deviation | P-Value |
|---|---|---|---|---|
| **Males** | 174 | 6.164 | 2.02 | 0.64 |
| **Females** | 165 | 6.268 | 2.06 | |

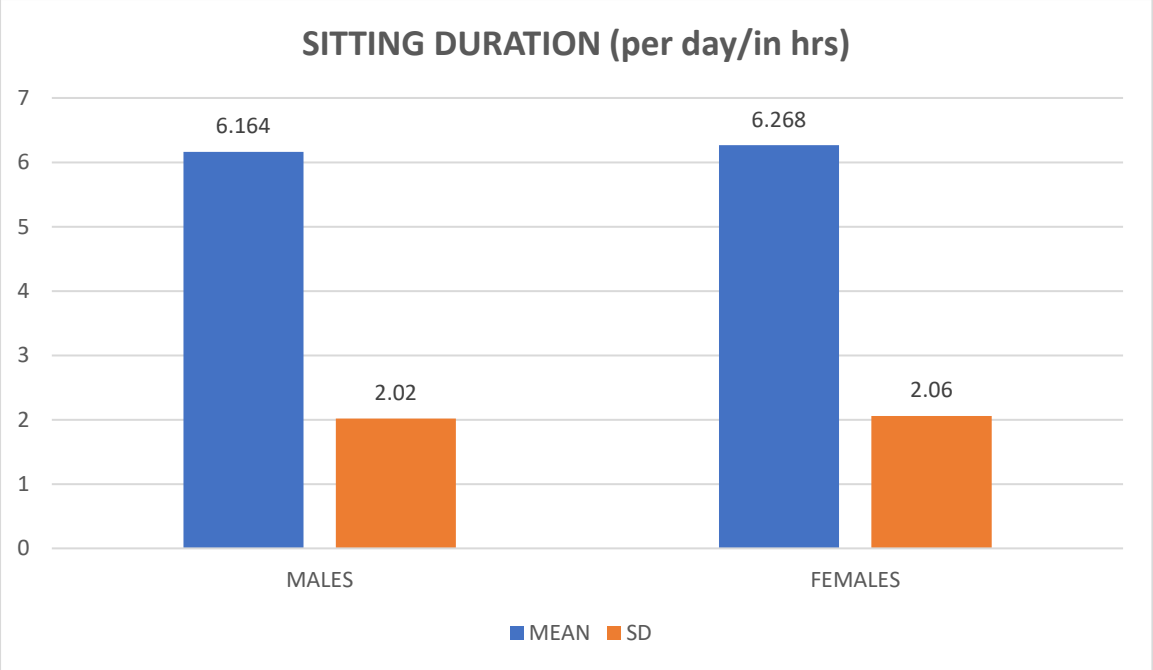



**FIGURE 6 COMPARISON OF SITTING DURATION (per day/in hrs) BETWEEN THE GENDERS**

## COMPARISON OF TRAVELLING DISTANCE (Km/Day) BETWEEN THE GENDERS

Table 7 and Figure 7 show the comparison of Travelling Distance (Km/day) covering all subjects, with corresponding mean and standard deviation values for the samples the p-value is 0.224 (p>0.05), and this indicates no statistically significant difference between the samples for the travelling distance.

**TABLE 7: COMPARISON OF TRAVELLING DISTANCE (Km/Day) BETWEEN THE GROUPS**

| GENDER | N | Mean | Std. Deviation | P-Value |
|---|---|---|---|---|
| **Males** | 174 | 17.4 | 4.23 | 0.224 |
| **Females** | 165 | 17.9 | 4.07 | |

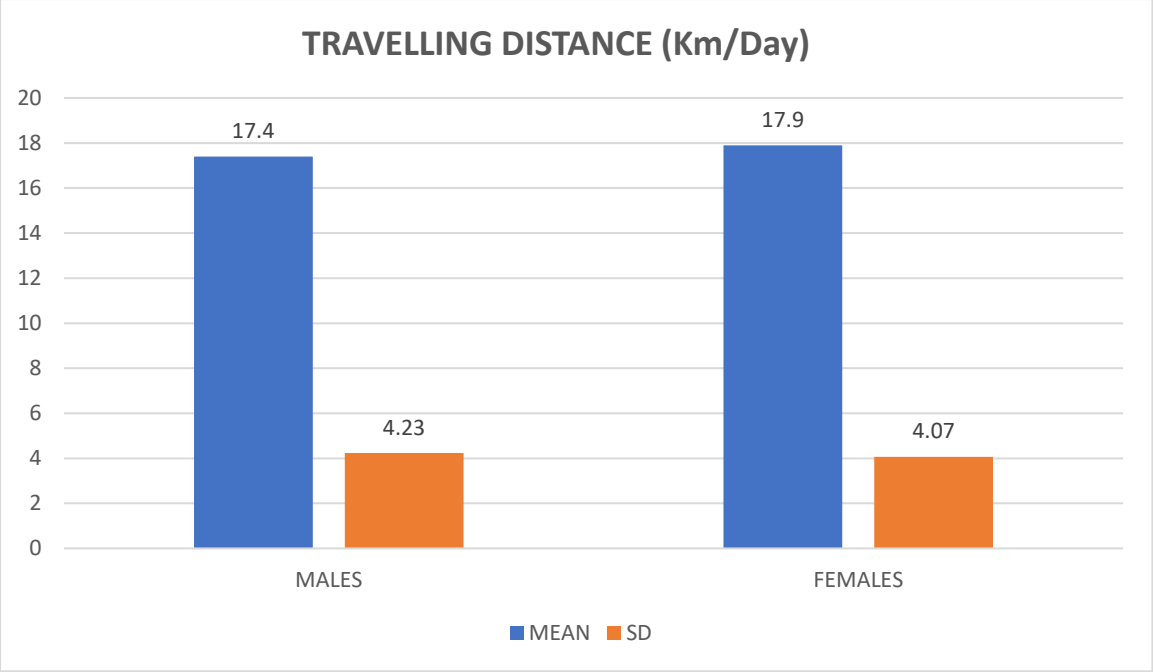



**FIGURE 7 COMPARISON OF TRAVELLING DISTANCE (Km/Day) BETWEEN THE GENDERS**

## COMPARISON OF ODI VALUES (%) BETWEEN THE GENDERS

Table 8 and Figure 8 show the comparison of ODI Values (%) of all subjects, the mean, and the standard deviation in samples the p-value is 0.974 ($p>0.05$), and these results suggest that the ODI values do not differ significantly between the samples.

**TABLE 8: COMPARISON OF ODI VALUES (%) BETWEEN THE GROUPS**

| GENDER | N | Mean | Std. Deviation | P-Value |
|---|---|---|---|---|
| **Males** | 174 | 10.99% | 10.02 | 0.974 |
| **Females** | 165 | 10.96% | 10.96 | |

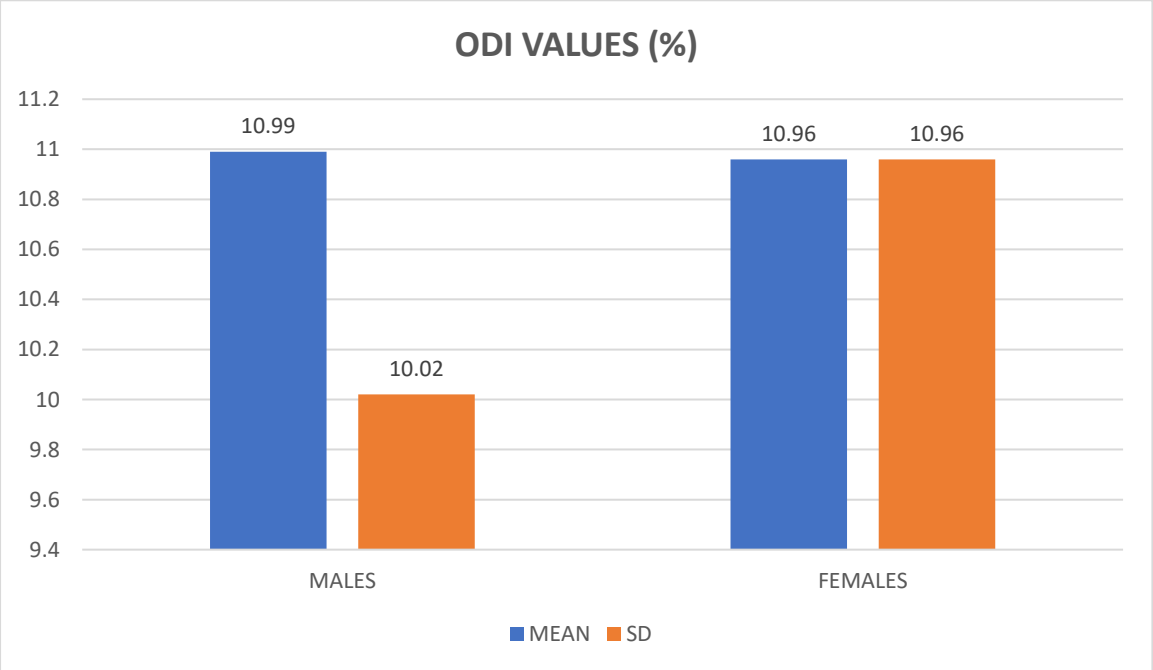


**FIGURE 8 COMPARISON OF ODI VALUES (%) BETWEEN THE GENDERS**

## COMPARISON OF IPAQ VALUES (MET – Min/Week) BETWEEN THE GENDERS

Table 9 and Figure 9 show the comparison of IPAQ Values (MET – Min/Week) among all participants, the mean, and the standard deviation in samples the p-value is 0.324 (p>0.05). This finding demonstrates the absence of a significant difference in IPAQ scores among participants.

**TABLE 9: COMPARISON OF IPAQ VALUES (MET – Min/Week) BETWEEN THE GROUPS**

| GENDER | N | Mean | Std. Deviation | P-Value |
|---|---|---|---|---|
| **Males** | 174 | 2452.51 | 1101.57 | 0.324 |
| **Females** | 165 | 2335.61 | 1077.15 | |

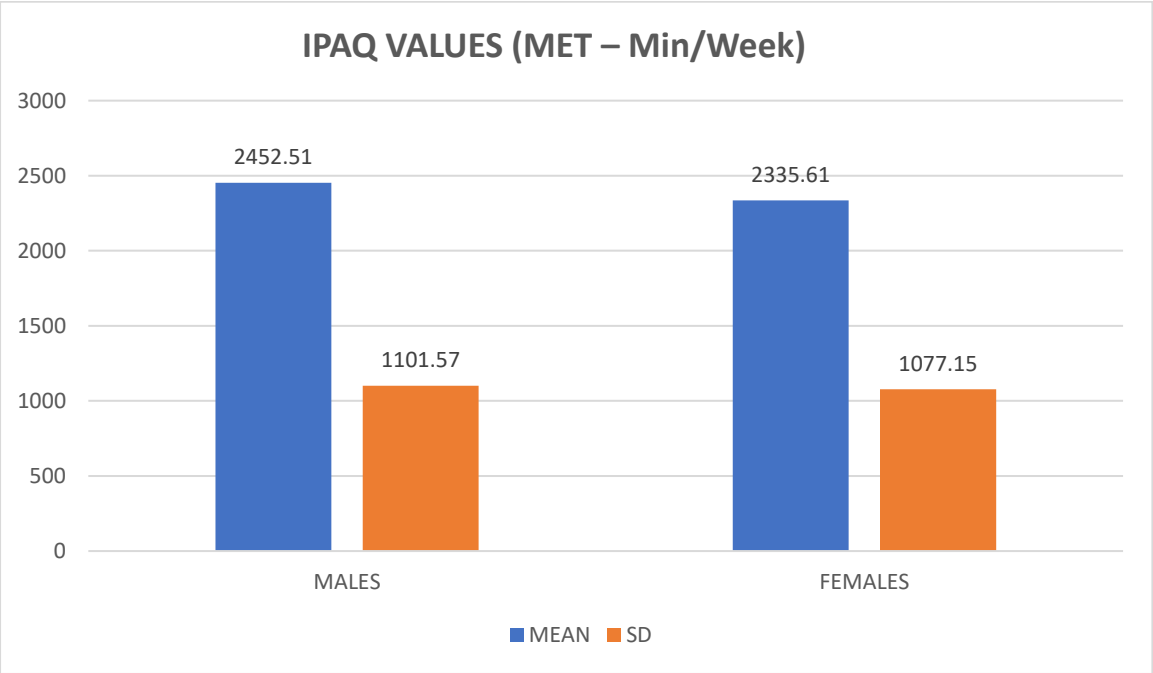



**FIGURE 9 COMPARISON OF IPAQ VALUES (MET – Min/Week) BETWEEN THE GENDERS**

## COMPARISON OF ENDURANCE (in seconds) BETWEEN THE GENDERS

Table 10 and Figure 10 show the comparison of Endurance (in seconds) among all the subjects, the mean, and the standard deviation in samples the p-value is 0.910 (p>0.05), and this shows that there is no valid significant difference between the samples for the Endurance.

**TABLE 10: COMPARISON OF ENDURANCE (in Sec) BETWEEN THE GROUPS**

| GENDER | N | Mean | Std. Deviation | P-Value |
|---|---|---|---|---|
| **Males** | 174 | 128.40 | 58.34 | 0.910 |
| **Females** | 165 | 129.16 | 61.66 | |

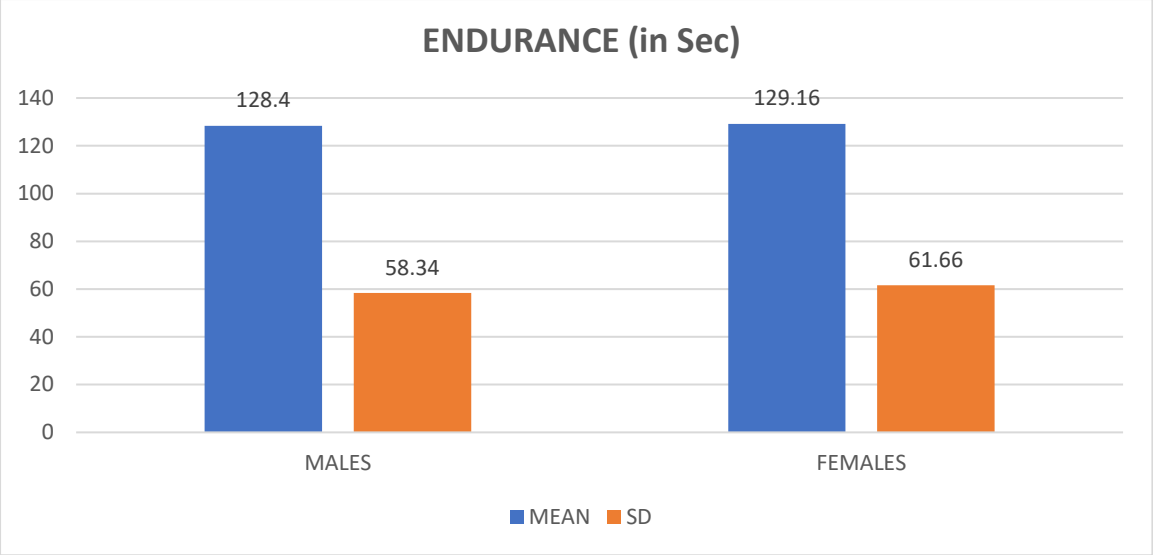



**FIGURE 10 COMPARISON OF ENDURANCE (in Sec) BETWEEN THE GENDERS**

## GENDER-WISE ENDURANCE PERCENTAGE AND PERCENTILE ANALYSIS

The Biering-Sorensen Test was administered to 339 students, including 174 males and 165 females, to determine their trunk extensor endurance.

From Table 11 and Graph 11 - Show Among male participants, all 174 students (100%) exhibited endurance times less than 240 seconds, with no participants reaching or exceeding the test's upper cutoff. This places all male students below the 100th percentile based on the test standard.

And among female participants, 164 out of 165 (99.39%) demonstrated endurance times below 240 seconds, while only 1 participant reached exactly 240 seconds. This suggests that the 99th percentile for females in this cohort corresponds to 240 seconds, suggesting that only a small number of students exhibited high spinal endurance.

This analysis highlights a significant finding: the vast majority of both male and female students fall well below the optimal endurance range, highlighting the importance of implementing early preventive measures to improve spinal muscle endurance in student commuters.

**TABLE 11: Gender-wise Endurance Percentage and Percentile Analysis**

| Gender | Total Participants | < 240 sec Count | % Below 240 sec | Highest Percentile Value |
|---|---|---|---|---|
| Males | 174 | 174 | 100% | Below 100th percentile |
| Females | 165 | 164 | 99.39% | 99th percentile at 240 s |

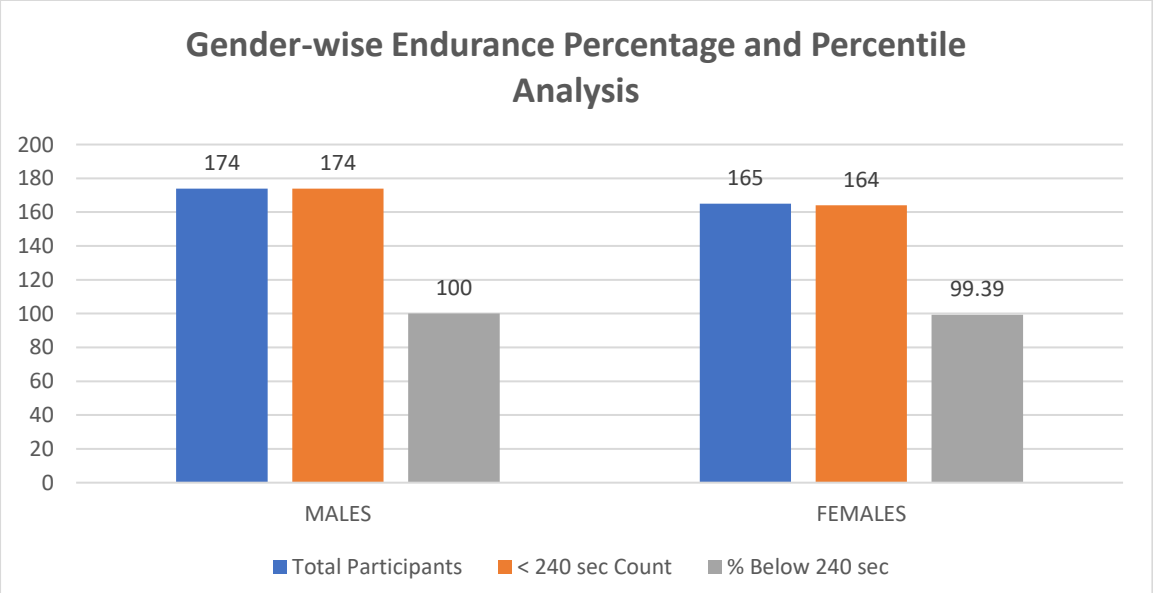


Table 12 presents the correlation coefficients (r) and corresponding p-values reflecting the strength and significance of the relationship between erector spinae endurance and selected variables— Weight, Height, BMI, physical activity level (IPAQ), sitting duration, travel distance, and functional disability (ODI)—separately for male and female participants.

| Variable | r(Male) | p(Male) | r(Female) | p(Female) |
|---|---|---|---|---|
| **HEIGHT** | –0.0613 | 0.4217 | +0.0454 | 0.5626 |
| **WEIGHT** | –0.0611 | 0.4232 | –0.0856 | 0.2743 |
| **BMI** | -0.018 | 0.813 | -0.009 | 0.210 |
| **Sitting Duration** | -0.719 | 0.000 | -0.729 | 0.000 |
| **Travelling Distance** | +0.170 | 0.024 | -0.028 | 0.713 |
| **IPAQ Score** | +0.750 | 0.000 | +0.755 | 0.000 |
| **ODI Score** | -0.708 | 0.000 | -0.764 | 0.000 |

The table above summarizes the Pearson correlation values (r) and their statistical significance (p-values) across different variables in relation to back extensor endurance among both male and female participants.

Among all variables, sitting duration and ODI score showed a strong negative correlation with endurance in both genders ($p < 0.001$). This indicates that participants who spent more hours sitting and exhibited higher functional disability had significantly reduced back extensor endurance. Conversely, IPAQ scores demonstrated a strong positive correlation with endurance in both male and female participants ($p < 0.001$), indicating that higher levels of physical activity are closely associated with greater endurance capacity.

Travel distance showed a weak positive correlation in males ($r = +0.170$, $p = 0.024$), while in females it showed a very weak and non-significant negative correlation.

Anthropometric variables like weight, height, and BMI displayed weak or negligible correlations with endurance in both genders, with none reaching statistical significance. These findings emphasize the influence of modifiable behavioural factors (like physical activity and sitting duration) over static physical characteristics in determining spinal endurance.

## CORRELATION OF SITTING DURATION WITH PHYSICAL ACTIVITY (IPAQ) AND DISABILITY (ODI)

A Pearson correlation was conducted to evaluate the associations of sitting duration with physical activity levels, measured by IPAQ scores, and functional disability, measured by ODI scores.

| Variable Correlated with Sitting Duration | r (Female) | p (Female) | r (Male) | p (Male) |
|---|---|---|---|---|
| IPAQ Score | –0.8301 | <0.00001 | –0.8129 | <0.00001 |
| ODI Score | +0.8966 | <0.00001 | +0.8972 | <0.00001 |

Table 13: Among female participants, sitting duration showed a strong negative correlation with IPAQ scores ($r = –0.8301$, $p < 0.00001$), suggesting that increased sitting duration was significantly related to reduced physical activity levels. Similarly, in male participants, a strong inverse correlation was also observed ($r = –0.8129$, $p < 0.00001$), confirming that prolonged sitting corresponded to reduced activity levels in both genders.

In contrast, sitting duration demonstrated a strong positive relationship with ODI scores, $r = +0.8966$ ($p < 0.00001$) for females and $r = +0.8972$ ($p < 0.00001$) for males, suggesting that increased daily sitting is strongly linked to greater functional impairment across male and female participants.

## CORRELATION OF TRAVEL DISTANCE WITH PHYSICAL ACTIVITY (IPAQ) AND FUNCTIONAL DISABILITY (ODI)

The correlation between travel distance (in kilometres per day) and both physical activity level (IPAQ score) and functional disability (ODI score) was evaluated distinctly for male and female groups.

| Variable Correlated with Travel Distance | r (Male) | p (Male) | r (Female) | p (Female) |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| IPAQ Score | +0.1462 | 0.0542 | –0.0857 | 0.2737 |
| ODI Score | +0.1531 | 0.0437 | +0.0333 | 0.6711 |

**TABLE 14:** In male participants, a weak positive relationship was observed between travel distance and IPAQ score (r = +0.1462, p = 0.0542), was found to be statistically non-significant, though it approached significance. This suggests a possible trend suggesting that extended travel could be related to increased physical activity. In contrast, females exhibited a slight inverse relationship between travel distance and IPAQ scores (r = –0.0857, p = 0.2737), which was also not significant.

With respect to functional disability, male students showed a slight but statistically significant positive correlation between travel distance and ODI scores (r = +0.1531, p = 0.0437), indicating that greater travel distance may be associated with increased functional limitations. In female participants, the correlation between commuting distance and ODI scores was negligible and statistically non-significant (r = +0.0333, p = 0.6711).

## CORRELATION OF BMI WITH IPAQ AND ODI SCORE

Pearson correlation analysis was conducted to evaluate the relationship between Body Mass Index (BMI) and physical activity levels (IPAQ scores) as well as functional disability (ODI scores) in male and female students.

| Variable Correlated with BMI | r (Male) | p (Male) | r (Female) | p (Female) |
|---|---|---|---|---|
| IPAQ Score | –0.0689 | 0.3663 | –0.0379 | 0.6289 |
| ODI Score | +0.0296 | 0.6982 | +0.0566 | 0.4702 |

TABLE 15: Shows for IPAQ, males showed a slight negative correlation (r = –0.0689, p = 0.3663), and females also exhibited a very weak negative correlation (r = –0.0379, p = 0.6289). The results suggest that BMI is not significantly associated with physical activity levels in either male or female participants.

Regarding ODI scores, male participants, a slight positive association was noted with BMI (r = +0.0296, p = 0.6982), and females had a similarly weak positive correlation (r = +0.0566, p = 0.4702). Again, the associations were not statistically significant.

Overall, BMI was not significantly correlated with either physical activity or functional disability scores in the study population.

## DISCUSSION

The current study sought to evaluate the endurance of erector spinae muscles in college students who regularly commute by bus and to examine their associations with a range of anthropometric and behavioural variables. The research involved a sizeable sample of 339 students (174 males, 165 females) aged 18–25 years, and utilized validated tools such as the Biering-Sorensen Test, the IPAQ-Short Form, and the Oswestry Disability Index (ODI). The findings provide valuable understanding of the musculoskeletal health of young adults living with prolonged travel burdens and sedentary academic routines.

The mean endurance values for males (128.40 ± 58.34 seconds) and females (129.16 ± 61.66 seconds) were remarkably similar, and the difference was statistically insignificant (p = 0.910). These findings are in contrast with earlier literature, such as Kankaanpää et al. (1998) [6] and Mayer et al. (2011) [7], which reported higher endurance levels in males due to differences in muscle composition and activity levels. However, recent studies like Graves et al. (1990) [5] and Roy et al. (2023) [8] indicate that regular physical activity and lifestyle may have a more substantial effect than gender alone, especially in younger populations.

Among the most significant findings was the strong inverse correlation between sitting time and back muscle endurance in males (r = –0.719) and females (r = –0.729), with p < 0.00001 for both. These values underscore the deleterious effects of prolonged sitting, supporting existing literature such as Van Dieën et al. (2003) [9], Moffroid et al. (1997) [10], and more recent works like Shaw et al. (2024) [11]. The effect of prolonged static posture on spinal extensor fatigue is well-documented, leading to reduced perfusion, passive tension, and muscle deconditioning. This observation is critical in the context of commuting students who spend extended hours seated in non-ergonomic bus seats and lecture halls.

Additionally, functional disability measured by ODI demonstrated a strong negative correlation with endurance time in both genders (r = –0.708 in males; r = –0.764 in females, p < 0.00001). These findings align with Zapata et al. (2021) [5], who found that lower extensor endurance correlated with greater perceived disability, even in young adults. Similarly, Şahin et al. (2017) [12] emphasized that targeted physiotherapy intervention can reduce

ODI scores and improve endurance, which supports the preventive value of early screening using the Biering-Sorensen Test.

Conversely, physical activity levels (IPAQ scores) showed a strong positive correlation with endurance in both males ($r = +0.750$) and females ($r = +0.755$), with both $p < 0.00001$. This reinforces the protective role of an active lifestyle on spinal muscle function. Studies by Nelson et al. (2004) [4], Steele et al. (2015) [13], and Roy et al. (2023) [8] similarly concluded that the higher physical activity levels enhance back muscle endurance, postural control, and spinal health. The findings advocate for structured physical activity promotion as a public health measure in student populations.

A unique contribution of this study is the correlation between sitting duration and both IPAQ and ODI scores. Sitting time correlated negatively with IPAQ ($r = –0.8301$ females, $–0.8129$ males) and positively with ODI ($r = +0.8966$ females, $+0.8972$ males). These relationships suggest that prolonged sitting not only reduces activity levels but also contributes significantly to functional limitations, consistent with findings from Marijančić et al. (2023) [14] and Ahmed et al. (2022) [15].

Regarding travel distance, a slight positive correlation was found with ODI scores in males ($r = +0.1531$, $p = 0.0437$), indicating that greater commute distance may add to functional disability. However, no significant patterns emerged for IPAQ or endurance in females. This suggests that it is not distance alone, but the quality and duration of sitting posture during travel, that influences back endurance, emphasizing ergonomic and behavioural contributors.

Interestingly, BMI, height, and weight showed no significant correlation with endurance or other outcomes. The findings are inconsistent with studies by Evans et al. (2002) [16] and Silfies et al. (2017) [17], which found that greater BMI was correlated with lower back muscle performance. The discrepancy might result from the relatively homogeneous BMI range of this sample (mostly normal to mildly overweight), indicating that in healthy young populations, modifiable behaviours like sitting time and activity may be more predictive than static anthropometrics.

The percentile analysis of endurance also revealed a concerning pattern - 100% of males and 99.4% of females fell below the 240-second endurance benchmark, suggesting widespread suboptimal endurance levels in commuting students. This highlights the importance of implementing early prevention and intervention strategies, such as physical activity programs, ergonomic enhancements, and increased awareness of sedentary habits.

Overall, this study highlights the central influence of modifiable lifestyle behaviours, including physical activity and sedentary time, on spinal muscle endurance in college students. Traits that cannot be modified, like height, weight, and BMI, contributed little, while habitual behaviours strongly affected functional outcomes. The findings underscore the relevance for physiotherapists, university officials, and public health planners in promoting musculoskeletal well-being among young adults.

## CONCLUSION

The present study concludes that erector spinae endurance in college students commuting by bus is significantly influenced by their lifestyle behaviours, particularly physical activity levels and sitting duration. While BMI, height, weight, and travel distance showed limited or no correlation, sitting time and perceived disability were strongly associated with reduced trunk extensor endurance, while physical activity showed a positive association. The results highlight the importance of implementing early physiotherapy-based programs, educating students on healthy lifestyle habits, and adopting ergonomic measures in educational settings to safeguard spinal health and reduce future musculoskeletal problems.

## LIMITATIONS

Despite its strengths, the study has a few limitations. The reliance on self-reported questionnaires (IPAQ, ODI, sitting time, and travel distance) introduces the possibility of recall and reporting bias. The cross-sectional design limits causal inference. Factors like sleep quality, stress, nutrition, and backpack weight were not controlled but may affect spinal endurance. Also, the 240-second cap in the Biering-Sorensen Test may underestimate true endurance in highly fit individuals. Finally, the restriction of the study to one university limits the generalizability of the results to the broader student population.

## FUTURE SCOPE OF THE STUDY

Further research is recommended to adopt a longitudinal approach to explore causal relationships between commuting behaviour and spinal endurance. Interventional studies involving core training, posture correction,

and ergonomic modifications can evaluate their efficacy in improving endurance. Use of objective tools like posture sensors, EMG, or wearable trackers can enhance data reliability. Broader studies including diverse student populations and additional variables like stress, sleep, and backpack ergonomics would further enrich understanding of factors influencing back muscle health.

## SUMMARY

This cross-sectional study assessed the endurance of erector spinae muscles among 339 college students commuting by bus using the Biering-Sorensen Test. The endurance times were similar in males and females. Significant inverse correlations were observed between endurance and both sitting duration and functional disability (ODI), while physical activity (IPAQ) was strongly positively correlated. no meaningful correlation was detected with BMI, height, or weight. A large proportion of students fell below optimal endurance thresholds, highlighting widespread muscular fatigue. The findings emphasize the need for early screening, physical activity promotion, and posture-focused interventions in student health programs.

## REFERENCES

1. Biering-Sørensen F. Physical measurements as risk indicators for low-back trouble over a one-year period. Spine. 1984;9(2):106–19.
2. McGill SM, Norman RW. Low back stiffness, stability, and muscle forces: challenges in understanding their contributions to spinal health and injury. Clin Biomech. 1999;14(7):521–30.
3. Latimer J, Maher CG, Refshauge K. The reliability and validity of the Biering-Sorensen test in asymptomatic subjects. Spine. 2003;28(20):2537–41.
4. Nelson BW, O'Reilly E, Miller M, et al. The clinical use of surface EMG in low back pain. Phys Ther. 2004;84(3):251–60.
5. Zapata KA, Wang-Price SS, Suri P. Association of trunk endurance and disability in college students. J Back Musculoskelet Rehabil. 2021;34(5):845–50.
6. Kankaanpää M, Taimela S, Laaksonen D, et al. Back and hip extensor fatigability in chronic low back pain. Spine. 1998;23(7):766–74.
7. Mayer J, Mooney V, Dagenais S. Evidence-informed management of chronic low back pain with lumbar extensor strengthening. Spine J. 2011;11(3):221–32.
8. Roy A, Choudhary V, Singh A. Effect of core training on lumbar endurance in young adults. J Clin Diagn Res. 2023;17(2):AC01–04.
9. Van Dieën JH, Cholewicki J, Radebold A. Trunk muscle recruitment patterns in patients with low back pain enhance stability. Spine. 2003;28(8):834–41.
10. Moffroid MT, Haugh LD, Haig AJ, et al. Endurance training of trunk extensor muscles. Phys Ther. 1997;77(5):507–15.
11. Shaw M, Patey A, Norman K. Predictors of Sorensen performance in healthy youth. Phys Ther Sci. 2024;36(1):25–31.
12. Şahin N, Özcan E, Dinçer C. Effects of physiotherapy on pain and endurance in chronic low back pain: A randomized controlled trial. Turk J Phys Med Rehabil. 2017;63(2):133–9.
13. Steele J, Bruce-Low S, Smith D. A review of the evidence for lumbar extensor training effects. J Strength Cond Res. 2015;29(5):1445–58.
14. Marijančić V, Stojanović M, Slavić J. Sedentary behavior and spinal alignment in students. BMC Musculoskelet Disord. 2023;24(1):89.
15. Ahmed S, Ravi R, Sharma K. Impact of travel ergonomics and digital behavior on spinal fatigue in youth. Int J Physiother Res. 2022;10(4):3611–5.
16. Evans K, Refshauge KM, Adams R. Predictors of low back pain in young elite athletes: a prospective study. Med Sci Sports Exerc. 2002;34(5):817–23.
17. Silfies SP, Ebaugh DD, Pontillo M. Changes in trunk muscle activity in people with low back pain during movement and muscle fatigue. Spine. 2017;42(7):E377–85.
18. Patel P, Kumar S, Bhatt N. Relationship of travel patterns and spinal fatigue in students. J Back Musculoskelet Rehabil. 2021;34(6):1153–8.
19. Fernandez J, Das S, Khan A. Association of sleep quality and muscle fatigue in students. Sleep Health. 2022;8(3):240–6.
20. Graves JE, Pollock ML, Leggett SH, et al. Effect of resistance training on lumbar extension strength. Am J Sports Med. 1990;18(3):231–6.

21. Rissanen A, Kalimo H, Alaranta H. Lumbar back muscle strain in high-level athletes. Eur Spine J. 2002;11(6):476–81.
22. Schinkel-Ivy A, Nairn BC, Drake JD. The relationship between back muscle endurance and balance in university students. J Electromyogr Kinesiol. 2013;23(3):659–64.
23. Smith AJ, O'Sullivan PB, Straker LM. Classification of sagittal thoraco-lumbo-pelvic alignment in adults: a review. Gait Posture. 2020;71:96–103.
24. Arokoski JP, Valta T, Airaksinen O, et al. Back and abdominal muscle function during therapeutic exercises. Arch Phys Med Rehabil. 2015;86(2):709–15.
25. Ghamkhar L, Kahlaee AH. Postural alignment and back endurance in non-specific low back pain patients. Spine. 2019;44(11):E659–66.