Exploring the Influence of Sitting Posture and Duration on Low Back Pain Among Adolescents

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The main contribution of this study was to fill in the gap in the literature regarding the influence of gender, weight, sitting posture, and sitting duration on low back pain (LBP) among adolescents aged 14 to 19 years. Findings revealed no significant gender differences in LBP scores, contrary to some literature. Weight, however, showed a notable association with LBP scores, aligning with existing research indicating increased strain on the lower back due to excess weight. Sitting posture and duration showed no significant associations with LBP scores. However, the combined effects of awkward posture and sitting duration suggest it might affect LBP prevalence. This study utilized an analytical cross-sectional design with a sample size of 45 students, employing anonymous stratified sampling by age. Data analysis techniques included the two-sample Mann-Whitney U test, Pearson chi-square, and multivariate analysis of variance (MANOVA). The findings of this study highlight the importance of addressing both sitting posture and duration among adolescents to mitigate the risk of developing LBP. Interventions that promote ergonomic practices and encourage regular breaks from prolonged sitting may help reduce the burden of LBP in this population, ultimately improving their overall well-being and academic performance.

Keywords: Low Back Pain; Prevalence; Sitting Posture; Sitting Duration.

Introduction

Sedentary behavior and prolonged sitting have been shown to adversely affect health, contributing to a range of issues including obesity, cardiovascular diseases, and musculoskeletal disorders. Notably, prolonged sitting can lead to metabolic changes that increase the risk of developing chronic conditions. Physiologically, sitting for extended periods can result in decreased blood flow, muscle stiffness, and strain on the lumbar spine [1–5]. This strain can cause or exacerbate low back pain (LBP), which is a significant health concern worldwide.

The World Health Organization states that LBP is "between the lower edge of the ribs and the buttock. [6] Although not typically life-threatening, it has emerged as a significant health concern with widespread implications beyond physical discomfort [5]. Not only are 60 to 80% of the worldwide population suffering from LBP, it continues to be the primary source of disability among individuals under the age of 45, accounting for roughly 40% of all compensation claims in the United States [7 8 9 10 11]. LBP affects over a quarter of the working population annually, with a 60-80% lifetime occurrence rate [12 13]. Many LBP cases result in extended work absences, exceeding 90 work days lost [14].

Although LBP is commonly associated with adults, it has increasingly affected the younger population [6]. This is not merely a matter of physical discomfort; LBP leads to school absenteeism and the potential loss of education and is known to be a huge contributor to increased LBP occurrence as an adult [15, 16]. The growing use of mobile devices has recently led people to utilize portable equipment despite not having a traditional desk [17]. Sitting at a table and sitting with a chair with a backrest are the positions most frequently used by a college student while working on a laptop, resulting in them frequently assuming uncomfortable sitting positions, heightening the risk of musculoskeletal disorders [18 19]. It has been observed that even brief periods of computer work while seated in a chair with a backrest can lead to pain and discomfort in the long run [20 21 22]. Indeed, one of the major causes of LBP is the sitting posture and duration. Although sitting alone is not inherently associated with LBP, the risk increases substantially when combined with co-exposure factors like awkward postures, according to Lis et al. (2016) [1]. A cohort study by Da Silva et al. (2019) found that awkward postures and prolonged sitting result in a high risk of LBP recurrence for adults and adolescents [3]. Jung et al. (2020) asked participants to maintain a static sitting posture using mobile devices for 30 minutes, furthering this observation by highlighting the significance of slumped postures in increasing LBP frequency in college students [23]. Research has demonstrated that prolonged periods of poor sitting posture can increase LBP and discomfort in the lumbar region [24] see Figure [1.1].

Moreover, while the aforementioned studies include both

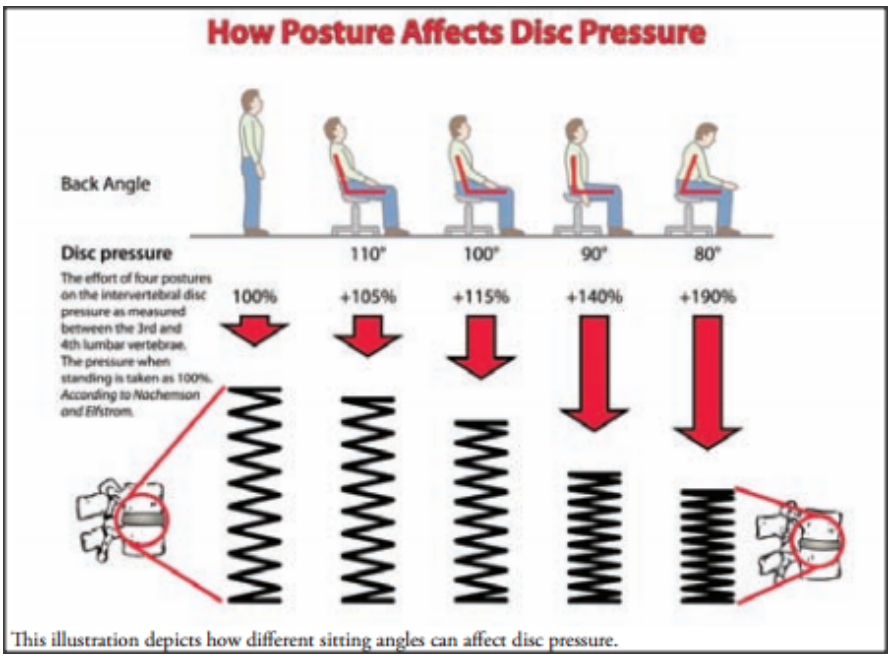


Fig 1.1: Different postures can induce different lumbar pressure and discomfort [1].

sitting posture and duration, sitting duration alone can also greatly contribute to LBP. Previous studies revealed a clear positive association between duration and LBP intensity and frequency [25 26]. Through various questionnaires, a study from Saudi Arabia confirmed this by showing that 61.5% of college students who sit for over 4 hours reported having LBP8.

Nevertheless, there is insufficient research into the effects of posture and duration on pre-college students (14 to 19 years) who are much younger than college students. The age gap is a significant factor because, in various studies, LBP increases with age [2]. LBP's causes, especially among pre-college students, are multifaceted. Studies disagree on the relevance of sex in the frequency of experiencing LBP, with some arguing that it takes an important role [27 28 29] while others don't [30 31]. A similar debate happens with disagreements about body weight [32 33]. Those who found correlations cannot confidently conclude that these factors contribute to LBP, and multiple research ended with differing results.

To investigate the various causes further, this study aims to determine the prevalence of LBP among students attending an American high school in Northern Taiwan by examining how LBP correlates with the students' sitting posture and duration. Moreover, considering the debates on gender and body weight, these factors will also be included in the analysis. Doing so will better understand the factors contributing to LBP in pre-college students, thereby facilitating the development of more targeted and effective preventative measures to reduce the risk of chronic pain development [34]. Based on existing literature, the initial hypothesis is that increased awkward sitting posture and sitting duration cause increased LBP prevalence.

Methods

Study design, study population and sampling technique

An analytical cross-sectional study explored the prevalence of LBP among students aged 14 to 19 years attending an American high school in Northern Taiwan. A targeted sample was essential to investigate potential associations between LBP and students' sitting posture and duration. The study adopted anonymous sampling, stratifying the student population by age. This sampling methodology aims to create a representative sample of students, providing valuable insights into the prevalence of LBP and its potential correlation with sitting posture and duration.

Study Measures and Definitions

This study examines the term "sitting" within the framework of Western standards. "Sitting" is based on the Handbook of Human Factors and Ergonomics and is defined as an upright posture where the head and torso are in a vertical position, the lower legs are bent at approximately 90 degrees at the hips and knees, and the feet are planted firmly on the round [24,37] see Figure 2.1]. It's important to note that sitting differs significantly in non-Western cultures. In regions like India and Southeast Asia, it remains typical to observe people sitting cross-legged on theground, assuming squatting positions with knees bent severely and thighs positioned close to the body or kneeling [38].

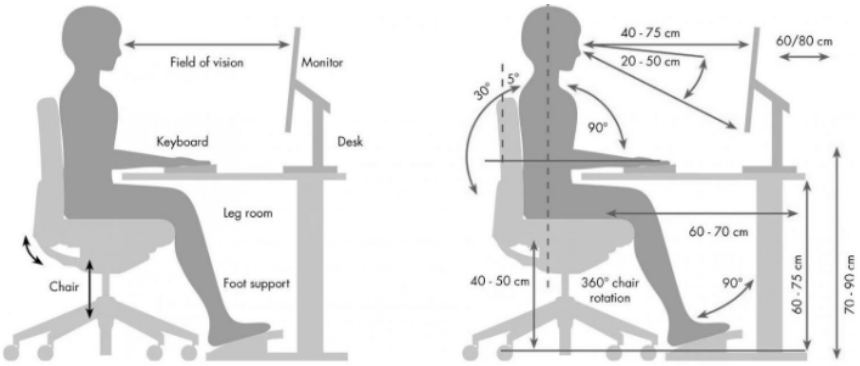


Fig 2.1: The upright sitting posture[35].

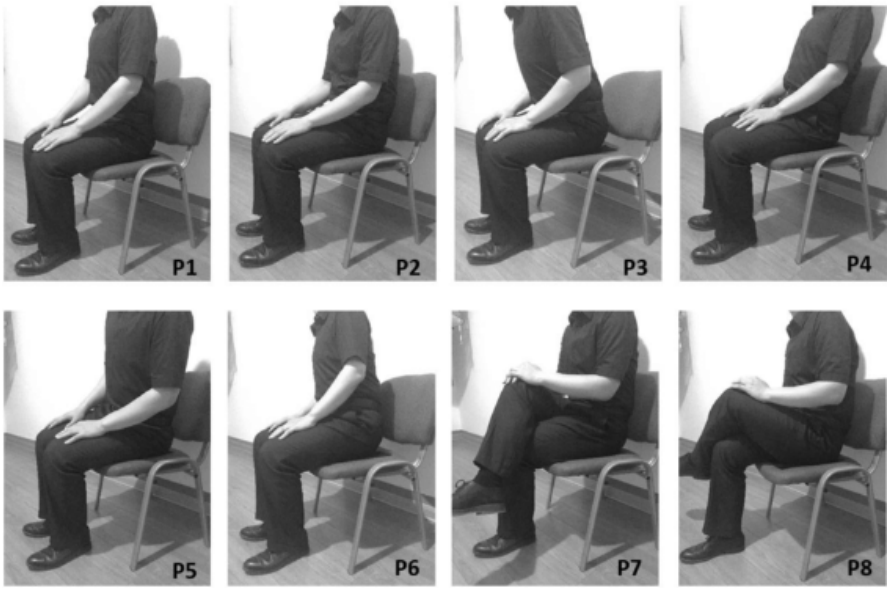


Fig 2.2: Other than P1, all the other postures are considered awkward[36].

While these alternative sitting practices are prevalent, this study does not delve into their discussion.

On the other hand, awkward postures encompass a range of positions, such as twisting, bending, reaching, pulling, or lifting. They involve tasks requiring an individual to work with their hands elevated above their head, their elbows positioned higher than their shoulders, or maintaining a bent neck or back at an angle exceeding 30 degrees, thereby lacking adequate support and the ability to change[39]. For this study, awkward postures will be defined as anything that deviates from the standard sitting posture [see Figure 2.2].

There's no universal definition for prolonged sitting as various organizations and studies propose different thresholds. For instance, Hadgraft et al. (2016) suggest that any continuous sitting duration in the workplace exceeding 30 minutes qualifies as prolonged[40]. In contrast, the European Union defines all types of prolonged sitting as those over 120 minutes[41]. However, an Asian study by Yates et al. (2018) defined prolonged sitting as a continuous sitting of 7.5 hours[35]. Due to the massive difference, this study will base its definition on the class time of the school. Notably, the American school in this study sets the class length, which often involves sitting for the whole time, at 85 minutes, indicating its consideration of this duration as a suitable range that will not result in negative health effects. As a result, prolonged sitting in this study will be defined as 85 minutes of continuous sitting.

Data collection

Three types of questions were included in this online study: General questions, Sitting posture, and sitting duration. Each of these questions is derived from past surveys that have been validated and have pre-college students as its target audience. Additionally, the survey was pre-tested on 5 students to estimate

the time of the survey and check for ambiguity. 45 participants filled out the survey. The quantitative data becomes statistically significant as the number of subjects exceeds 30[42]. All participants filled out the survey in a room within the school.

The general questions of LBP in this study are based on Akbar et al. (2019), which studied the relationship between LBP and school bag weight for pre-college students[27]. Though modified slightly to fit the online survey, this set of questions was used because the target respondents are also pre-college students. The survey first asked background questions such as age, sex, and body weight to address previous discussions on their influence on LBP. Afterward, the questions move on to the topic of lifetime prevalence, in which this question is asked: "Have you ever felt low back pain that lasted a day or longer? (Yes, no, I don't remember)" On the other hand, 6 months prevalence was asked: "Have you felt low back pain that lasted a day or longer in the last six months? (Yes, No, I don't remember)." Lastly, some questions involve the frequency and intensity of LBP. On questions that require a scale, the study used a 0–10 Numeric Rating Scale (NRS) to rate the intensity of LBP. The NRS is used because its benefits are validated quickly and are easy to use[43].

Questions involving sitting posture are from the Questionnaire on young people's body awareness and postural habits (Q-BAPHYP)[44]. This questionnaire was used for people from 15 to 18 years old and has been validated. This tool aimed to assess young individuals' self-perception regarding their posture in various settings or dimensions, including the classroom, leisure activities at home (such as using a computer or watching TV), and rest periods. It also aimed to capture their movements during activities like picking up objects and carrying backpacks and bags, as well as the disciplinary approaches employed by teachers in the classroom. Responses to each item featured five alternatives: never, rarely, often, always, and don't know/don't remember. The Likert scale employed in this survey was bipolar, with a starting point of -2 for positive assertions (indicating good postural habits) and 2 for negative assertions. Numerical values were assigned to each item, contributing to scores for each dimension. Positive scores suggested that individuals adequately perceived their body posture, while negative scores indicated inappropriate postural habits. A score of zero could result from a combination of negative and positive answers in the dimensions or from responses with a value of zero (indicating uncertainty or lack of recall).

Lastly, questions involving sitting duration are from the Adolescent Sedentary Activity Questionnaire (ASAQ) [see Figure 2.3] from the Sedentary Behaviour Research Network, a research institute focusing on sedentary behavior. This survey is tailored for adolescents and aims to gather data on various sedentary behaviors, including screen time, educational activities (such as homework), travel, cultural pursuits (like reading and crafts), and social engagements (such as relaxing with friends or attending church). The questions have been validated[45]. The format is slightly modified to fit Google Forms, though the questions remain the same.

Ethical Concerns

Informed consent, which includes the description of the study procedures and the right to refuse or withdraw, was obtained from all participants prior to their involvement in the study. Before the survey was distributed, the researcher informed school authorities and teachers about the purpose and nature of the study. Students were not made aware of the survey beforehand to minimize bias in their responses. Participants were assured that their involvement was voluntary, and they could withdraw from the study at any point. No personal information beyond age, gender, body weight, and survey responses were collected to respect the participants' privacy. The researcher did not have access to students' contact information, though the study's purpose and the researcher's contact details were provided to address any concerns. Confidentiality was maintained throughout, and only aggregated, de-identified data was analyzed. The school administration retained any additional personal information, ensuring the privacy and ethical treatment of the participating students.

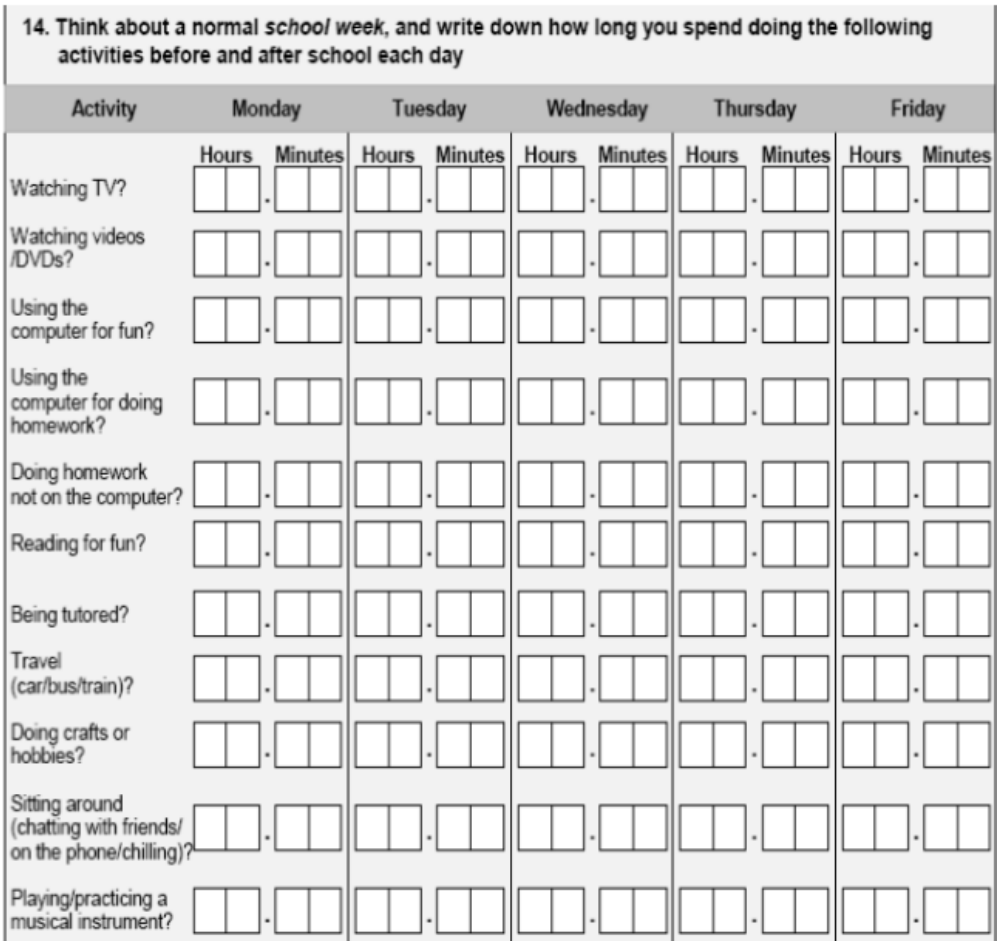
Data Analysis

Data analysis techniques included the two-sample Mann-Whitney U test, Pearson chi-square, and multivariate analysis of variance (MANOVA). These statistical methods were used to explore potential associations between LBP and factors such as sitting posture, duration, gender, and body weight. The Mann-Whitney U test was employed to compare LBP scores between genders, while Pearson chi-square was used to analyze categorical data. MANOVA was conducted to assess the combined effects of multiple independent variables on LBP prevalence.

Results

Study Group Demographics

None of the 45 students refused to participate when invited. 4 students were initially excluded from the analysis due to inaccuracies in their responses, where they reported spending more than 24 hours per day sitting. 7 students were also excluded from the analysis because they filled out "I do not remember" in any of the questions involving having LBP in the past. The data is analyzed via SPSS Statistics[47] and Statistic Kingdom[48], where the significance level of .05 was used. Table 1 shows the socio-demographic factors of the participants in the study. The mean age of the participants was 16.8 years, and 44% were male. Here, the population excludes those who responded "I do not remember" and those whose responses exceeded 24 hours.



14. Think about a normal *school week*, and write down how long you spend doing the following activities before and after school each day

Activity	Monday		Tuesday		Wednesday		Thursday		Friday	
	Hours	Minutes	Hours	Minutes	Hours	Minutes	Hours	Minutes	Hours	Minutes
Watching TV?										
Watching videos /DVDs?										
Using the computer for fun?										
Using the computer for doing homework?										
Doing homework not on the computer?										
Reading for fun?										
Being tutored?										
Travel (car/bus/train)?										
Doing crafts or hobbies?										
Sitting around (chatting with friends/ on the phone/chilling)?										
Playing/practicing a musical instrument?										

Fig 2.3: Part of the Adolescent Sedentary Activity Questionnaire (ASAQ)[46].

Gender & Weight

The LBP prevalence score was calculated on a scale of 0 to 2, with 1 point assigned for each positive response to questions about experiencing LBP. Before conducting further analysis, a normality test using the Shapiro-Wilk test was performed due to the small sample size (n less then equal to 50). The results indicated that neither the LBP scores nor the body weight distribution followed a normal distribution, as both had p-values significantly lower than the significance level. Given the non-normal distribution of the data, the two-sample Mann-Whitney U test was used. The analysis showed no statistically significant difference between genders in terms of LBP scores, with a p-value of 0.1094. This result suggests that gender does not have a significant impact on LBP scores in this sample. However, when comparing LBP scores with body weight, the Mann-Whitney U test revealed a statistically significant difference, with a p-value of 1.238e-7. This indicates that body weight does have a significant impact on LBP scores within this sample [see Table 2].

Sitting Posture

There are two types of questions related to sitting posture: 12 questions belong to the good ones, while 20 are categorized as awkward ones. The response is ranked from 1 to 5, with the score for good and bad sitting posture being the sum of all the 12 and 20 responses, respectively. The null hypothesis is that both types of sitting posture are independent of the LBP score for the population of adolescents in the American School. The alternative hypothesis is that bad sitting posture is not independent of the LBP score for the population of adolescents in the American School.

Good posture with LBP score

The Pearson chi-square and linear-by-linear association will be analyzed here since one involves the significance level while the other involves a linear relationship. The former, having a p-value (.854) greater than $\alpha = .05$, suggests that there is no sufficient statistical evidence to reject the null hypothesis that

sample characteristic	n	%	M	SD
Sex				
Male	15	44		
Female	19	56		
Age				
15	5	14.7	16.8	1.14
16	7	20.6		
17	14	41.2		
18	5	14.7		
19	3	19: 8.8		
Weight Range				
40-49	7	20.6	58.6	11.31
50-59	15	44.1		
60-69	4	11.8		
70-79	7	20.6		
80-89	1	2.9		
Have LBP**				
Yes	18			
No	16			
Don't remembe	6			

Table 1 Socio-demographic characteristics of the students, 2024.The mean for weight range is calculated based on the median of each range (ex. 40-49 → 44.5).**Based on responses to "Have you ever felt low back pain that lasted a day or longer?" and "Have you felt low back pain that lasted a day or longer in the last six months?

there is no association between good sitting posture and low back pain. On the other hand, the latter, having a p-value of .177, signals that a linear relationship is not found between the two variables. However, it is much more significant than the Pearson significance.

Awkward posture with LBP score

Similarly, the Pearson Chi-Square, having a p-value (.227) greater than $\alpha = .05$, suggests that there is no sufficient statistical evidence to reject the null hypothesis that there is no association between awkward sitting posture and low back pain. On the other hand, linear-by-linear association, having a p-value of .263, signals that a linear relationship is not found between the two variables.

Sitting Duration

Sitting duration was measured in minutes, with any total sitting time exceeding 85 minutes considered prolonged. The statistical

	Gender	Weight
Shapiro Test	0.000003406	0.0003865
Two sample Whitney	0.1094	1.24E-07

Table 2 Gender & weight comparison.The greener the color, the more significant the data is.

analysis in this section employs the two-tailed Point Biserial Correlation, as it is designed to compare continuous data (sitting duration) with a categorical variable (LBP score). The null hypothesis posits that sitting duration is independent of LBP scores among adolescents in the American School, while the alternative hypothesis suggests that sitting duration may be associated with LBP scores.

Sitting duration and LBP score

The analysis yielded a Pearson Correlation coefficient of -.109. The negative value implies a slight decrease in LBP scores as sitting duration increases. However, the correlation's magnitude is minimal, indicating a weak relationship between the two variables. Moreover, the significance level suggests that this observed correlation is not statistically significant. Consequently, we cannot confidently assert that a true relationship exists between sitting duration and LBP scores in the studied population. The result is visualized in Fig 3.

Fig. 3. Heatmap comparing LBP with good posture, awkward posture, and sitting duration.

Fig 3: The upright sitting posture[35].

Fig. 3 presents a heatmap illustrating the correlations between LBP (Lower Back Pain) scores, good posture, awkward posture, and sitting duration. The heatmap uses both color and size to convey the strength and direction of these correlations. Blue squares represent positive correlations, while red squares indi-

cate negative correlations. The size of the squares corresponds to the strength of the correlation, with larger squares indicating stronger relationships. The overall correlations in this heatmap are weak, with none of the variables showing strong associations with LBP. This suggests that within this sample, factors like posture and sitting duration do not have a significant impact on LBP scores.

Effects of Two Factors

Many sources have claimed that the effects of bad posture and long duration combined can cause a higher frequency of LBP. As such, the multivariate analysis of variance (MANOVA) was used, in which multiple dependent variables by one or more factor variables are inputted. The null hypothesis is that the effects of awkward posture & sitting duration will be independent of the LBP for the population of adolescents in the American School. The alternative hypothesis is that the impact of awkward posture & sitting duration is not independent of LBP for the population of adolescents in the American School.

Effects of Awkward Posture & Sitting Duration on LBP Score

To determine the appropriate multivariate test statistic between Pillai's Trace, Wilk's Lambda, Hotelling's Trace, and Roy's Largest Root, three preliminary tests were conducted: the Shapiro-Wilk test for normal distribution, Levene's Test for homogeneity of variances, and Pearson's Correlation Coefficient for linearity. For the data on awkward posture, the Shapiro-Wilk test indicates insufficient evidence to be normally distributed; likewise, Pearson's Correlation Coefficient demonstrates inadequate evidence to conclude that a linear relationship exists between LBP score and awkward posture in the population. For the data on sitting duration, the Shapiro-Wilk-test concludes that the difference between the data sample and the normal distribution is not big enough to be statistically significant; similarly, Pearson's Correlation Coefficient revealed that the difference between the sample correlation and the expected correlation is not big enough to be statistically significant. Lastly, Levene's test was conducted to find the homogeneity of the three factors: bad posture, sitting duration, and LBP score. The test used an F distribution with degrees of freedom (1,66) and a right-tailed approach. The null hypothesis was rejected as the p-value was less than the significance level, indicating that some groups' variances are unequal. The p-value was extremely small at 1.11712e-11, suggesting a negligible chance (1.1e-9%) of a Type I error. Given these violations of multivariate normality, homogeneity of variance-covariance matrices, and linearity, the choice of the appropriate MANOVA test statistic was critical. Hotelling's Trace was selected due to its robustness in handling violations of these assumptions. This robustness makes Hotelling's Trace the most suitable choice for conducting the MANOVA in this study, ensuring that the analysis could provide reliable results despite the issues identified in the data. By choosing Hotelling's Trace, the study acknowledges and addresses the assumption violations, offering a more accurate assessment of the combined effects of awkward posture, sitting duration, and their interaction on LBP scores. The results yielded a p-value of .058, indicating that the overall effect was not statistically significant at the conventional alpha level of .05. Specifically, the p-value for awkward posture was .069. For sitting duration, it was .139. These p-values are greater than .05, further supporting the conclusion that neither awkward posture nor sitting duration statistically affects the LBP score. Thus, based on the results, the null hypothesis cannot be rejected, suggesting that there is no significant multivariate effect of awkward posture and sitting duration on the outcome variable when assessed together in the MANOVA.

Summary

Other than body weight, all tests suggest a relationship between the factors cannot be found given the available data. The only exception might be the MANOVA test, which has a p-value of 0.058 and indicates a possible relationship. The result is visualized in Table 3.

Discussion

The study's findings suggest that gender is not a significant determinant of LBP prevalence among adolescents, consistent with the literature by Kopec et al. (2004) and Amyra Natasha et al. (2018). However, this contradicts earlier studies like Linton et al. (1998), Hoy et al. (2010), and Akbar et al. (2019), which found gender differences in LBP prevalence. Weight, on the other hand, did show a significant influence on LBP scores, supporting findings by Leboeuf-Yde (2000) that suggest increased weight places greater strain on the lower back, thereby contributing to LBP. Interestingly, the study did not find significant associations between sitting posture—whether good or awkward—and LBP scores. This contrasts with existing research by Jung et al. (2020) and Kim (2015), which found correlations between poor posture, prolonged sitting, and LBP prevalence. The weak and statistically insignificant negative correlation between prolonged sitting duration and LBP scores also warrants further scrutiny. This result challenges the assumption that longer sitting times invariably increase the risk of LBP and might suggest potential flaws in how sitting duration was measured or defined in this study. One possibility is that this research set the total sitting time that exceeds 85 minutes to be considered prolonged. This threshold was based on the target audience's school where 85 minutes is the maximum amount of sitting time to prevent health

Checking the hypothesis. ✓ : Significant, × : Not significant, ∼ : Not significant, but very close.

	Good posture	Awkward posture	Duration	Gender	Weight	Awkward + posture
LPB	×	×	×	×	✓	∼

Table 3 LPB

issues, including LBP. However, the selection of 85 minutes as the threshold may not fully capture the nuances of prolonged sitting in this adolescent population, potentially influencing the observed results.

Despite the lack of individual significance, the combined effects of awkward posture and sitting duration on LBP scores, explored through MANOVA, revealed a p-value that is very close to 0.05. While this does not reach conventional statistical significance, it suggests a trend where combined exposure to these factors might slightly elevate LBP risk, echoing observations by Lis et al. (2006). This indicates that while each factor alone may not significantly impact LBP, their combined effect might contribute to its prevalence.

The findings highlight several key points for various stakeholders. Clinicians should prioritize weight management in preventing and managing LBP among adolescents, potentially rethinking the emphasis placed on sitting posture and duration. Educators and school administrators might consider incorporating ergonomic design into school furniture and allowing breaks from prolonged sitting, as poor posture combined with extended sitting may increase LBP risk. Health education programs should also address weight management and other risk factors for LBP to raise awareness among students.

Several limitations should be considered when interpreting these results. First, the reliance on self-reported data may have introduced recall bias or inaccuracies, particularly in reporting sitting posture and duration. The exclusion of 11 students due to inaccuracies and unclear recall further reduces the sample size, potentially limiting the study's ability to detect significant effects. Moreover, this study was conducted with a small sample (n=45) from a single high school in Northern Taiwan, limiting the generalizability of the findings. Environmental factors, educational practices, and student demographics could vary significantly across different schools and regions, potentially influencing LBP prevalence.

Given these cautions, further investigation into the specific factors contributing to LBP among adolescents, including the role of ergonomic factors such as school furniture, could provide valuable insights for preventive measures. Studies can also focus on elements not explored in this study, such as cultural, socioeconomic, and environmental factors, as they could also play a role in LBP prevalence among adolescents. Longitudinal studies that track sitting habits over time may also be warranted to clarify further the long-term effects of sitting posture or duration.

Conclusion

This study investigates LBP prevalence among 14 to 19-year-old students in a Northern Taiwan American high school, and it hypothesizes that there will be a relationship between sitting posture and duration on LBP prevalence. Using stratified anonymous sampling, 45 participants completed an online survey on general LBP questions, sitting posture (via Q-BAPHYP), and sitting duration (from the Adolescent Sedentary Activity Questionnaire). Contrary to the initial hypothesis, sitting posture and duration did not significantly correlate with LBP prevalence. However, the combined effects of sitting posture and duration may have a possible impact due to a close p-value of 0.058. Future research can focus on either gathering a larger sample or conducting a longitudinal study to complete the picture of LBP and its factors.

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