

## Mathematical Prediction of Worst Sitting Posture in College Chairs: Risk of Back Disorder in College Going Population

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**Extended Abstract:** Multiple factors within the college scholarly lifestyle contribute to lower back pain, from lifestyle to outdated chair designs. While determining the exact causes of back pain can be difficult due to these multitude of factors, the most important center point around most of these variables is the chair. Chair designs commonly seen in schools and other centers of learning, especially earlier designs, often do not provide adequate support for relieving pressure on the back, which contributes overtime to back pain due to increased pressure on the lumbar part of the spine and the discs. A lot of this pressure comes from the 'mismatch' between furniture dimensions and the average body dimensions of those that use said furniture. This mismatch can be partially attributed as well to the static nature of the chair design. Most school chair designs are not adjustable and have a hard or non-flexible backrest, which would increase back pain for those whose bodies are not suited to the chair. Office chairs, meanwhile, commonly have adjustable elements such as a footrest and a seat height adjuster in order to minimize the pressure on the back and to encourage better posture. The two most common forms of chair design for long lectures within colleges are the high-school based ones, and the side desktop mounted lecture hall chairs. Preliminary studies show that students feel uncomfortable while using those chairs. Nonetheless, the students need to continue their posture in those unergonomic chairs, for an average of four days per week, for 5-6 hours each day. There is enough scientific evidence that awkward postures performed in the chairs are one of the main sources of long term chronic back pain and spine disorders including wear and tear. The aim of this paper is to use different postures that the students perform in the chair, translate them in 3DSSPP software to predict the worst posture in producing highest back compressive force. We will mathematically model different postures to predict the chance of college students to get back disorder.

*Keywords:* college; chair; mathematical; model; ergonomics; sitting; posture

### 1. Introduction

Within Ergonomics, the highest priority of risk factors to determine is how the back handles varying amounts of pressure over a long period of time. This is often researched within the category of manual lifting, due to its more proactive force on the back and easier capability of determining the long term impacts the back will have due to overexertion. However, this is not the only factor one must consider, as inactive tasks such as sitting can also have a chronic impact on the back if not handled properly. Multiple factors within the college scholarly lifestyle contribute to lower back pain, from lifestyle to outdated chair designs. While determining the exact causes of back pain can be difficult due to these multitude of factors, the most important center point around most of these variables is the chair.

Chair designs commonly seen in schools and other centers of learning, especially earlier designs, often do not provide adequate support for relieving pressure on the back, which contributes overtime to back pain due to increased pressure on the lumbar part of the spine and the discs. A lot of this pressure comes from the 'mismatch' between furniture dimensions and the average body dimensions of those that use said furniture. The research article, "Classroom Furniture Mismatch and Back Pain Among Adolescent School-Children in Abha City, Southwestern Saudi Arabia," by a group of researchers at King Khalid University in Saudi Arabia conducted a cross-sectional study on twelve intermediary and secondary (equivalent to elementary and high school) schools in Abha to determine the extensive mismatch. They concluded that there is indeed a high level of mismatch, and that said mismatch is correlated to back pain, specifically, "buttock-popliteal length/seat depth mismatch" as the most primary component with the mismatch between secondary students and the rate of mismatch being an average of "84.5%" of the tested (Assiri, 2019). This evidence suggests that the way the buttocks and popliteal lengths compare to the

depth of the seat can impact the most on the lower back. However, this mismatch was more prevalent among intermediary students, due to the chairs being “too high and too narrow,” there is still a prevalent mismatch even in secondary students (Assiri, 2019). While the study was that of their equivalent elementary and high schools within a foreign nation and not colleges in the USA, most of these same kinds of chairs used in high schools are often utilized in colleges as the basic form of seating, and thus would cause even more of a mismatch due to the increased size of the students compared to their high school counterparts.

## 2. Back Compressive Forces

The posture of slumping causes an increased curve on the spine compared to other postures, which puts more strain on the back, and thus an increase in back pain. As discussed with the UCLA Health about, “Ergonomics for Prolonged Sitting,” there is mention about what proper posture should be within sitting for minimizing pressure on the back, such as where the buttocks should be (back of the chair) or how the elbows can be placed on the desk (UCLA). Many of these attributes, while possible in an office chair, cannot be as adequately replicated with a static chair utilized in the classroom, which showcases that the posture while in a static chair is likely to not be of much use depending on the anthropometric dimensions of your body (UCLA).

The force exerted on the back, especially for much of the college population, is often enough to contribute towards lower back pain and chronically other back related issues. While not as strenuous as working a full time physically demanding job, there are forces still enacted that can overtime cause an increase of pressure, whether the person is actively working or even something as simple as standing or sitting. While there is not much I could find that is directly about the college going population, there is plenty of research for young adults as well as other factors that could throw off said research.

Compressive forces on the back, especially that of the disc, can be associated with that of lower back pain. Tetsuya Hasegawa and his colleagues had committed a study ultimately providing evidence for the association by separating groups of men, one with low back pain and one without, and then their “standing posture was assessed in each group, using a three-dimensional motion analysis system, force plates, and a spinal mouse,” especially with regard to their low back moment and intervertebral disc compressive force (Hasegawa, 2018). It was found that those that had higher compressive force and a bigger moment of the back were associated with also having low back pain, suggesting that the posture even while standing can put pressure on the back that can lead to long term back issues. The back compression forces from the results, for instance, indicated that people without lower back pain was around 8.22, while those with lower back pain had a compression force of 9.07 (Hasegawa, 2018). Similarly, the flexion of the lower back was 0.18 and 0.23 respectively (Hasegawa, 2018). This research indicates that some postures even while standing will increase compressive forces, and that there is a correlation between a higher compressed back and more back pain.

## 3. Conclusion:

When pressure in the spine is high over time, it can lead to the discs of the spine (vital for balancing and shock absorption) being ‘squished’ like a marshmallow. The disc then has less ‘flow’ from blood and can become dehydrated, leading to it becoming weaker and more painful for the body. This is the most prevalent part of any back pain caused by compression on the back, and thus the part to look for the most when simulating the back.

While there was existing research and literature done on the effects of compressing the spine in regards to long-term sitting, what has not been established well was how much pressure over time does it take for said issues to start processing. A limitation I found while researching and working on this was the overall chronic nature of back related issues. These kinds of pressures can last such a long time that there hasn’t been much established research beyond confirming the correlation exists. Furthermore, research based in the US was limited, with most being in colleges around the world instead of more relevant sources. This made some research harder, as it means to double check if the chairs are applicable in some way to that of US ones. The study is still ongoing on the mathematical modelling.

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