CADAVIZ Through the Lens of Evidence-Based Research: A Stratified Cross-Sectional Study

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Abstract

Context: Anatomy in Ayurveda, or Rachna Sharir, is deeply rooted in classical Sanskrit texts. Traditional lecture-based methods, with limited visual aids, often struggle to effectively convey the complex concept of Rachna Sharir. Innovative tools like a virtual dissection table (VDT) offer detailed visualization of human anatomy, making it easier for students to comprehend the intricacies of the subject with considerable ease. **Aim**: To assess the impact of a VDT in increasing the comprehension of Ayurvedic anatomy among students with varying academic performance levels. **Settings and Design**: This stratified cross-sectional Study was performed with first-year B.A.M.S students. **Materials and Methods**: A cohort of 30 students, stratified into high-, medium-, and low-performing groups, was subjected to a traditional lecture session, followed by an interactive session with VDT, CADAVIZ. To measure comprehension, pre- and post tests were conducted before and after CADAVIZ sessions, respectively. Statistical analysis aided in assessing the effectiveness of the VDT across different performance groups. **Results**: The study results indicate that post test scores for all three groups were higher than their respective pretest scores. Before the CADAVIZ session, Group A, Group B, and Group C had average pretest scores of 71.5% ± 1.58%, 59.76% ± 1.47%, and 50.25% ± 2.53%, respectively. However, after engaging with CADAVIZ, their post test scores increased to 96.66% ± 3.16%, 79.31% ± 3.42%, and 65.93% ± 1.05%, respectively. This reflects a percentage improvement of 35.18% ± 4.2% for Group A, 32.71% ± 3.0% for Group B, and 31.21% ± 3.0% for Group C. **Conclusions**: The study confirms that VDT, CADAVIZ, effectively enhance anatomical understanding in Ayurveda students, benefiting all groups regardless of their academic performance.

Keywords: Academic performance, Ayurvedic anatomy, inclusive learning, medical education technology, Rachna Sharir, virtual dissection table

Introduction

Ayurveda, the ancient Indian system of medicine, embraces a holistic approach to health. At its core is Rachna Sharir. It forms the anatomical foundation of Ayurvedic practice. Acharya Sushruta, revered as the *Father of Surgery*, pioneered dissection techniques to help practitioners understand human anatomy and the vital roles of cells, tissues, organs, and organ systems in health and healing.[1]

While central to Ayurvedic education, learning Rachna Sharir is a challenging task, especially for students with limited proficiency in Sanskrit as Ayurvedic texts are originally written in Sanskrit. For students with this issue of language barrier, grasping classical terminology becomes difficult, and even with translations, key concepts may be lost or diluted.[2]

Another challenge is the integration of modern and Ayurvedic anatomy. While many institutions emphasize modern anatomical dissection techniques, certain aspects of Rachna Sharir such as the concepts of sukshma sharir (subtle body) and karan sharir (causal

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body), often get overlooked. This imbalance makes it difficult for students to appreciate Ayurveda's holistic perspective.[3]

Then, there is the vast and complex curriculum. Rachna Sharir covers a vast array of topics, including but not limited to *Garbhavakranti*, *Garbha Sharir*, *Dashavidha, Garbha Lakshanas* (embryology), *Dhatu Sharir*, *Srotas Sharir* (histology), *Anguli Pramana*, *Shareera Pramana*, *Ayam-Vistara Nyaya* (anthropometry), and *Marma Sharir* (the study of vital points). The sheer volume and complexity of information to read and learn in a limited timeframe can overwhelm students, hindering their ability to grasp concepts.[4]

First-year B.A.M.S (Bachelor of Ayurvedic Medicine and Surgery) students also have no less clinical exposure as many institutions restrict their participation in outpatient department duties, resulting in a passive learning environment where theoretical knowledge falls short of real-world application.[5] Furthermore, traditional teaching methods, relying on rote memorization of Sanskrit verses, often fail to provide an interactive learning experience. The absence of 3D models, virtual dissections, or visualization tools limits engagement, particularly for complex anatomical structures.[6]

To bridge these challenges, integrating ancient wisdom with modern technology, such as a virtual dissection table (VDT), is crucial. CADAVIZ, the first VDT with a dedicated Ayurveda module, offers 3D visualization of core Ayurvedic concepts, transforming education into an interactive and immersive experience.[7] Figure 1 illustrates how CADAVIZ enhances the understanding of Marma points, providing precise insights into their structure, function, and significance. Figure 2 showcases how CADAVIZ aligns Ayurvedic anatomical concepts with modern scientific terminology, enabling students to interpret Rachna Sharir holistically.

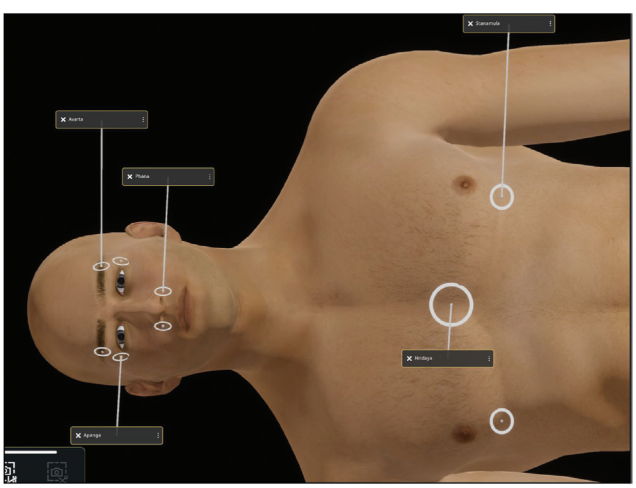

Figure 1: Concept of Marma points as visualized in CADAVIZ

While interactive tools like VDTs theoretically bridge traditional Ayurvedic knowledge with modern medical education, offering a more engaging and comprehensive learning experience, their practical effectiveness in Ayurvedic anatomy education remains largely unexplored. This research aims to bridge that gap by evaluating the impact of CADAVIZ on students' comprehension of Rachna Sharir. By assessing its effectiveness, we seek to establish that integrating VDT into the BAMS curriculum would be beneficial for all strata of students alike.

Materials and Methods

Study design

A stratified cross-sectional study was conducted with prior approval from the Institutional Ethics Committee and informed consent obtained from all participating students. The study aimed to assess the impact of the VDT, CADAVIZ, in enhancing the understanding of Rachna Sharir Marma points and anatomical planes in first-year Bachelor of Ayurvedic Medicine and Surgery (B.A.M.S.) students.

Study population

The study involved 30 first-year B.A.M.S. students who were selected based on their previous academic performance. The students were stratified into three groups: Group A (HP), Group B (MP), and Group C (LP). Table 1 defines the group allocation of the study

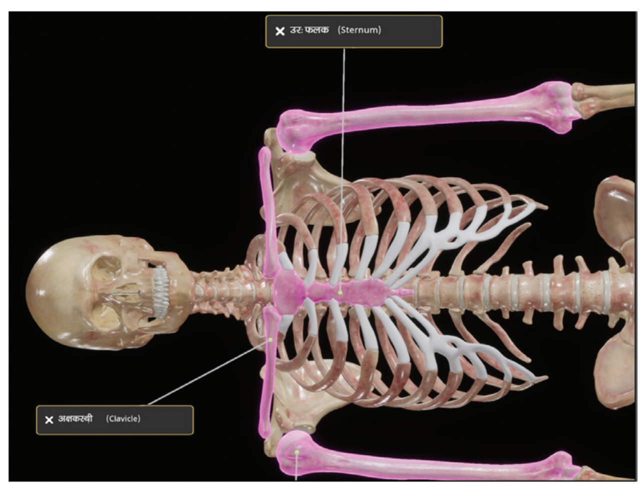

Figure 2: CADAVIZ for visualizing Ayurvedic terms with their corresponding anatomical terminologies

Table 1: Group allocation of study participants

Group	Stratification	Subject code	Sample size
A	High/Above Average Performers	HP	10
B	Medium/Average Performers	MP	10
C	Low/ Below Average Performers	LP	10
Total			30

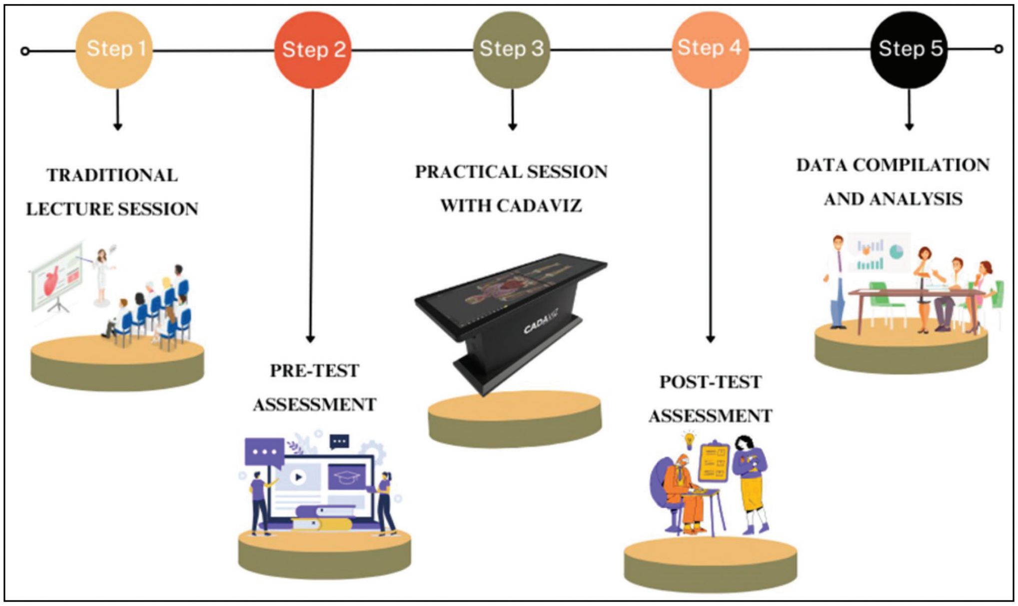

Figure 3: Study design of the research study

participants. Group A contained 10 high-performing or above-average students, Group B contained 10 medium performers or average students, and Group C contained 10 low-performing or below-average students. Stratification was done using the students' cumulative scores from prior academic tests, ensuring a representative distribution across varying performance levels.

Intervention and procedure

Figure 3 describes the study design of the structured teaching protocol each group underwent:

Traditional lecture

The session began with a 1-hour lecture covering the theoretical aspects of Marma points and anatomical planes. The lecture aimed to provide a foundational understanding of these key anatomical concepts.

Pre-test assessment

Immediately following the lecture, students took a pretest consisting of 10 validated multiple-choice questions (MCQs) designed to assess their understanding of the topics presented in the lecture. The MCQs were carefully selected to cover the key points from the lecture, ensuring a reliable measure of preexisting knowledge.

Practical session with CADAVIZ

After an hour-long break, students participated in a hands-on practical session using CADAVIZ, a VDT. This session allowed students to visualize and interact with 3D anatomical models, focusing on Marma points and anatomical planes. The VDT was used to enhance spatial understanding and anatomical visualization through interactive features.

Post test assessment

Upon completion of the practical session, a post test of equivalent difficulty to the pretest was administered to assess knowledge retention and the effectiveness of CADAVIZ in reinforcing the material covered during the lecture. The post test also consisted of 10 MCQs, identical in structure and content to the pretest, to ensure comparability.

Statistical analysis

Descriptive statistics were employed to summarize the pretest and post test scores for each group. To assess the effectiveness of the teaching methods, inferential statistical analyses, including paired t tests and ANOVA, were conducted to compare the differences in knowledge retention and learning outcomes between the pre- and post test scores for each group. The paired t test was used to evaluate within-group score improvements, while ANOVA was applied to assess whether there were significant differences in the post test score improvements between the high-, medium-, and low-performing groups.

Study outcome

The primary outcome of the study was to evaluate the impact of the CADAVIZ virtual dissection platform on the understanding of Marma points and anatomical planes. The comparison of pretest and post test scores within and between the three groups enabled an assessment of CADAVIZ's effectiveness in improving anatomical knowledge across students of varying academic abilities.

Ethical considerations

The study adhered to ethical guidelines, and informed consent was obtained from all participants. Participants were assured of their anonymity and confidentiality throughout the study. The research was conducted with the approval of the Institutional Ethics Committee, ensuring that all ethical standards were upheld.

Results

The results of the study are documented in Figures 4 and 5. In Figure 4 the comparison of pretest and post test results across three groups is indicated while, Figure 5 shows the comparison of the percentage increase in assessment scores across all three groups.

The results of the study indicate that the post test scores for all three groups, namely, Group A (HP), Group B (MP), and Group C (LP), are higher than the pretest scores. As observed in Figure 4, Group A, the high- or above-average performing (HP) group, showed maximum improvement in their scores. In the pretest, the participants achieved an average score of 71.5% ± 1.58%, demonstrating a strong baseline understanding of the material. Following the interaction with the VDT, CADAVIZ, their average post test scores increased to 96.66% ± 3.16%, representing a gain of 35.18 ± 4.2 [Figure 5] percentage points. This increase not only reflects the potential of the intervention to enhance knowledge but also highlights its ability to elevate even those who were already performing well to near-perfect levels of achievement.

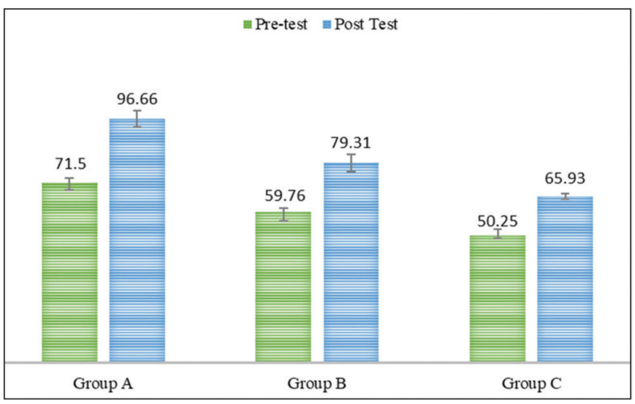

Figure 4: Comparison of pretest and post test results across three groups

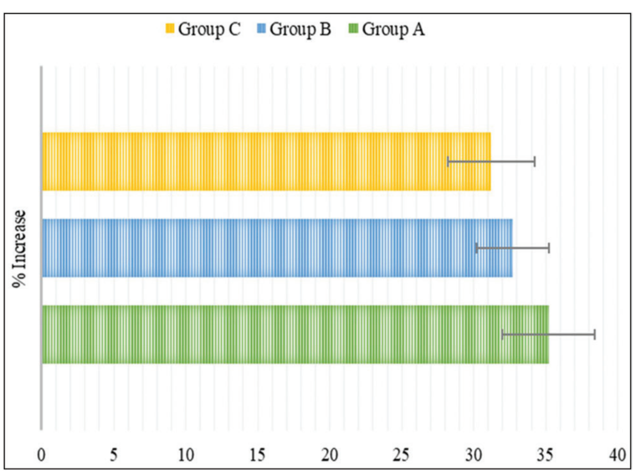

Figure 5: Comparison of percentage increase in assessment scores across three groups

Group B, with medium or average performers (MP), also performed better in post test than in pretest. Figure 4 demonstrates that, in pretest, participants belonging to Group B scored an average of 59.76% ± 1.47%, while post test scores following interaction with CADAVIZ increased to 79.31% ± 3.42%, marking a gain of 32.71% ± 3.0% [Figure 5].

As shown in Figure 4, Group C, composed of low-performing or below-average students, demonstrated most limited baseline knowledge, achieving an average pretest score of 50.25% ± 2.53%. Despite this lower starting point, they exhibited an improvement of 31.21% ± 3.0% [Figure 5] and their average post test scores was documented to 65.93% ± 1.05%. Although the absolute scores of this group were lower compared to those of the other two groups, the improvement is noteworthy and indicates that the intervention was beneficial even for participants who faced greater challenges in learning anatomy.

Interestingly, a comparative analysis of the post test score improvements among the three groups revealed no statistically significant differences ($P = 0.243$). As indicated in Figure 5, this finding suggests that CADAVIZ provides a level playing field for students, irrespective of their initial academic standing. The similar learning outcomes across all performance groups underscore the tool's ability to cater to diverse learning needs and support equitable educational experiences. Such results are particularly valuable in educational settings where varied baseline knowledge and skills can pose challenges to achieving uniform learning outcomes.

While the results of the study show a considerable improvement in the pretest and post test scores across all three groups (A, B, and C) with high-, medium-, and low-performing students, comparative statistics of the percentage increase in scores between groups reveal no significant differences. This indicates that CADAVIZ is beneficial for students across all performance levels, regardless of their academic standing. However, the only limiting factor in the current study is the small sample size. To further establish the efficacy of CADAVIZ in imparting the wisdom of Ayurveda, a study with a larger sample size will eventually be conducted.

Discussion

Medical education is undergoing a profound transformation with the integration of advanced digital tools such as augmented reality (AR), virtual reality, mixed reality (MR), and digital dissection tables.[8] These innovations have revolutionized the teaching and learning of anatomy by providing highly detailed, interactive, and immersive experiences. However, despite their advancements, these technologies primarily focus on visualizing human anatomy through the lens of modern medicine, often overlooking traditional medical systems like Ayurveda. This gap limits the understanding of the holistic principles of Rachna Sharir (Ayurvedic anatomy) as described in classical texts.[9]

Thus, there is an urgent need for implementation of educational tools that bridge the gap between Ayurveda and modern medical innovations, creating a harmonious integration of traditional knowledge with cutting-edge technology.[10] Such tools would ensure a more inclusive and comprehensive approach to medical education, enabling students to grasp both holistic Ayurvedic principles and contemporary anatomical insights with greater clarity and depth.

Integrating modern teaching tools into Ayurveda education is essential to enhance learning experiences and bridge the gap between traditional knowledge and contemporary medical practices.[11] Technologies such as virtual simulations, interactive e-learning, and AR can improve the understanding of complex Ayurvedic concepts, increasing engagement and knowledge retention while catering to diverse learning styles.

The integration of modern techniques with traditional practices represents a significant evolution in Ayurveda education. Numerous studies have documented the efficacy of VDT in teaching and learning anatomy.[12] However, the key challenge is determining whether these technologies can accurately visualize Ayurvedic terms and concepts as effectively as modern medical science. Ayurveda relies on unique anatomical and physiological interpretations that differ from conventional biomedicine, necessitating the development of specialized educational tools tailored to its philosophy.

The primary objective of this study was to assess the effectiveness of CADAVIZ, a VDT, in visualizing core Ayurvedic anatomical concepts. This approach aimed to enhance the comprehension of Ayurvedic principles through interactive and modern technological tools, fostering a more engaging and dynamic learning environment.

The study included students from diverse academic performance levels to evaluate whether CADAVIZ was equally beneficial for all learners. A key focus was to assess the impact of visualizing Ayurvedic concepts such as Marma points, in comparison to traditional teaching methods. The study also aimed to determine whether CADAVIZ was more effective than conventional lecture-based sessions, regardless of students' academic standing.

Significance of Marma points and anatomical planes

Marma points and anatomical concepts were selected for this study due to their fundamental importance in Ayurvedic medicine and their complex anatomical nature, which can be challenging to grasp through use of traditional teaching methods alone. Marma points are critical for understanding the therapeutic aspects of Ayurveda as they represent vital energy centers that influence physiological and pathological processes.[13] Mastery of these points requires precise anatomical and physiological knowledge for their effective application in clinical practice.

By visualizing these structures in detail using CADAVIZ, alongside corresponding anatomical landmarks, students were able to develop a more comprehensive understanding of these critical concepts. This interactive and immersive learning experience enabled students to better connect theoretical knowledge with practical applications, thereby enhancing retention and comprehension.

The study's findings, as illustrated in Figure 4, demonstrated that all three test groups—Group A (High Performers), Group B (Medium Performers), and Group C (Low Performers)—showed considerable improvement in their post test scores compared to their pretest scores. This indicates that visualizing and interactively exploring Marma points and anatomical planes on a life-sized human body significantly enhances knowledge retention compared to traditional classroom lectures.

Additionally, as depicted in Figure 5, while the magnitude of score improvement varied across groups, the trend consistently reflected enhanced comprehension and retention, facilitated by the VDT. Group A (High Performers) showed the greatest improvement, with post test scores increasing significantly, reflecting the tool's ability to refine and reinforce preexisting knowledge. Group B (Medium Performers) also exhibited substantial improvements, demonstrating that CADAVIZ effectively supports learners at an intermediate academic level. Group C (Low Performers), despite having the lowest pretest scores, displayed notable progress, suggesting that CADAVIZ helps bridge learning gaps and supports students who typically struggle with complex material.

These findings underscore the potential of CADAVIZ to address disparities in learning outcomes by offering an engaging and effective educational approach for students with varied academic capabilities. The results emphasize the utility of CADAVIZ in fostering consistent learning gains among students of differing academic performance levels. For educators, this highlights the potential of integrating advanced virtual tools into curricula to effectively support diverse learners.[14] Furthermore, the absence of significant differences in performance gains among groups suggests that CADAVIZ is not only effective but also inclusive, making it an ideal tool for reducing learning disparities.

This is particularly relevant in Ayurveda education, where traditional teaching methods may not always provide sufficient visualization of complex anatomical structures. With digital dissection tools like CADAVIZ, institutions can enhance the practical application of Ayurvedic principles, ensuring that students gain a well-rounded, integrative understanding of both traditional and modern perspectives.

Future prospects and limitations

While the study demonstrates the efficacy of CADAVIZ, it is essential to acknowledge potential limitations. One primary limitation is the small sample size, which may impact the generalizability of the findings. Future research should incorporate larger sample sizes to validate these results more robustly.

Additionally, factors such as varying levels of student engagement, prior exposure to virtual tools, and differences in instructional support during the use of CADAVIZ could influence learning outcomes. Future studies should explore these variables to provide a more nuanced understanding of CADAVIZ's impact.

Moreover, longitudinal studies could be conducted to assess whether the observed improvements in knowledge retention persist over time. Investigating how these virtual tools influence long-term clinical application of Ayurvedic concepts will be valuable for refining Ayurveda education strategies.

Conclusion

In conclusion, the results of the study indicate that VDT, CADAVIZ, has proven to be a valuable educational resource that enhances learning outcomes across students of different academic performance levels. Its ability to deliver consistent improvements, irrespective of academic standing, underscores its potential to promote equitable and effective education in anatomy and related fields.

As educational institutions increasingly adopt digital tools, CADAVIZ stands out as an exemplary model for leveraging technology to improve learning experiences for all students. By bridging the gap between traditional Ayurvedic knowledge and modern visualization techniques, CADAVIZ ensures that future healthcare professionals are well-equipped to integrate holistic principles with contemporary medical insights.

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Nil.

Conflicts of interest

There are no conflicts of interest.

List of Abbreviations

VDT: Virtual Dissection Table

Group A (HP): High-Performing or Above Average Students

Group B (MP): Medium Performing or Average Students

Group C (LP): Low-Performing or Below Average Students

B.A.M.S.: Bachelor of Ayurvedic Medicine and Surgery

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