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VIRTUAL REALITY AS A METHOD FOR STUDYING THE FUNCTIONAL ANATOMY OF THE FEMALE PELVIC FLOOR

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Abstract: Virtual reality is increasingly present in the academic world, especially in the health area, where it has proven to be an alternative and effective method for teaching, especially in human anatomy, simplifying the study of more complex content, such as the female pelvic floor. The objectives of this research were to review female pelvic functional anatomy and explore its study methods, in particular the use of virtual reality, comparing it to traditional teaching methods. The methodology involved a bibliographic search in databases such as Pubmed, Scielo and Google Scholar, resulting in the analysis of 39 articles, books and websites; published between 1995 and 2023, in English and Portuguese. The results highlighted the evolution of anatomy teaching techniques up to the present time, when the use of virtual reality emerges as an alternative methodology that overcomes the disadvantages of cadaveric dissection, while preserving its positive points, such as the stereoscopic view of the anatomical structures. The complexity of the female pelvic anatomy represents an obstacle to learning, but virtual reality enters this scenario as a solution, capable of facilitating the understanding of the structures of this region in an immersive and student-focused way. For exemplification purposes, how an application that uses virtual reality to teach the female pelvic floor works was explored. It was concluded that virtual reality is an excellent method for learning human anatomy, such as the female pelvic floor, which, despite being complicated, can be fully studied with the help of this effective technology.

Keywords: Anatomy, Pelvis, Educational Models, Virtual Reality.

INTRODUCTION

Knowledge of human anatomy forms the basis for medical practice, and its teaching included the development and improvement of various observation techniques that have been created over the years. (STIVAL; RIBEIRO; GARBELINI, 2023).

Throughout history, different ways of learning and documenting it have been used, according to Silva (2014), from Aristotle's comparative anatomy and the dissection of corpses much advocated by Galen in Ancient Greece, as cited by Calazans (2013), until the creation of artificial anatomical models, begun in Italy at the end of the 17th century.

In the current context, the expansion of health universities, the prevalence of traditional teaching, the reduction in workload, the difficulty and bureaucratization in obtaining and maintaining cadavers, and the ethical issue of this process have made anatomical research and teaching difficult. by dissection, a gold standard consolidated since ancient times. (ARAÚJO JÚNIOR et al., 2020; LOSCO et al., 2017)

Based on this principle, alternative teaching methods and resources, as mentioned by Colares et al. (2019), can act in the medical training scenario as facilitators of learning dense and complex content, such as the anatomy of the female pelvic floor (ELLINGTON et al., 2019).

Dietrich, Gehrich and Bakaya (2008) highlighted that understanding the anatomy of the pelvis is essential for several areas of health sciences, especially due to its structural and functional complexity. The female pelvis, the focus of this study, is composed of an integrated network of muscles, ligaments, blood vessels and nerves that support the pelvic visceral organs.

Petros and Woodman (2007) highlighted that disturbances in any component of this network affect the physiology of the region and can lead to multisystem symptoms that make diagnosis and therapeutic management difficult.

Pandeva et al. (2019) stated that understanding this region is necessary for clinical and surgical practices in different specialties, but also that, due to its complexity, it represents an obstacle to learning for many students.

According to McLachlan and Patten (2006), anatomical models, plastination, analysis of radiological images (such as MRI - magnetic resonance imaging) and 3D anatomical impressions are some possibilities that can facilitate the understanding of pelvic anatomy.

Recently, interest in virtual reality, as pointed out by Zhao et al. (2020), has been increasing in medical education and, according to Colares et al. (2019), this interest is especially true for surgical training during residency and for teaching anatomy, offering students a simulation to quickly identify structures in 3D.

The advancement of virtual reality dates back to the 1960s, in the entertainment industry. Kim and Ahn (2021) explained that this technology is composed of an image that offers a realistic virtual environment to the user, providing real-time feedback and allowing practice on a virtual patient.

Thus, for Melo et al. (2007), the purpose of virtual reality is to provide more immersive and engaging experiences with applications in different domains, from theoretical education to practice.

This new model of active methodology addresses several topics and structures at the same time, passing information in a more complete, easy and direct way, helping, as reported by Campos et al. (2022), in the training of students' investigative reasoning in the health area, in addition to encouraging students' critical thinking.

Since ancient times, learning about human

anatomy took place through the dissection of cadavers as it presented several advantages that, at the time, other methods did not provide, as explained by Araújo Júnior et al. (2020); That's why it became the gold standard of this teaching. However, McLachlan and Patten (2006) highlight that with this technique new problems also came to light.

This way, virtual reality comes into play not only to overcome the obstacles present in learning human anatomy in medical schools (ARAÚJO JÚNIOR et al., 2020), including those caused by dissection, as highlighted by De Faria et al. (2016), as well as to maintain the advantages achieved by Galeno's technique, as stated by Campos et al. (2022).

According to Colares et al. (2019), new technological tools are increasingly part of our daily lives, improving the different methods used in teaching and learning. In this context, virtual reality can be a form of study that students in the health area find easier to use - as they are familiar with the technology - and adapt quickly (CAMPOS et al., 2022), also stimulating their involvement and learning in classes, as highlighted by Kim and Ahn (2021).

Mystakidis (2022) stated that another technology that can be used to teach anatomy is the metaverse, based on the convergence of technologies such as virtual reality and augmented reality, in order to intertwine physical reality with virtual reality, and can be used by several individuals simultaneously. This new technology has great potential in the academic world as a teaching tool capable of radically changing education. The metaverse - thanks to its ability to capture 360-degree panoramic photos and other features - allows information-rich learning in a hybrid and informal way, as an alternative teaching method.

Finally, it is worth highlighting that, with the growth of virtual reality, some studies also point to concern about the cyber disease "cybersickness", which includes some symptoms such as nausea, fatigue, headache, tension, postural instability and vomiting, which They are possibly caused by visual immersion and movements in the virtual environment (RAMASERI CHANDRA; EL JAMIY; REZA, 2022; WEECH; KENNY; BARNETT-COWAN, 2019).

METHODOLOGY

Bibliographic search carried out to assess articles on the proposed topic. These articles were consulted in the PubMed, SciELO and Google Scholar databases. The research was carried out by crossing the following descriptors: "anatomy", "pelvis", "educational models" and "virtual reality". 39 articles, books and websites written in English and Portuguese, published between 1995 and 2023, were used.

GOALS

Review female pelvic functional anatomy and its study methods, collect current information about virtual reality in medical education and compare it to traditional teaching methods.

RESULTS

Virtual reality is a technology that creates a simulated environment through technological devices with the aim of providing an immersive experience to the individual using it. It works, according to Vince's (2004) explanation, by combining hardware, - which consists of the physical components of these devices, which can be glasses, helmets, gloves, motion controls and sensors - and software, - which are the programs or systems used on these devices to create the graphics and environments that underlie the virtual reality immersion experience.

Tori, Kirner and Siscoutto, (2006; p.13)

defined it as follows: "Virtual Reality is, first and foremost, an "advanced user interface" to access applications running on the computer, having as its characteristics the visualization of, and movement in real-time, three-dimensional environments and interaction with elements of that environment."

According to Tori and Hounsell (2020), the history of virtual reality began approximately in the second half of the 20th century, when the first ideas and technologies began to be developed. Devices were created that offered immersive sensory experiences through simulated videos, sounds, scents and wind. Inventions were emerging, and with each innovation, it was possible to glimpse the potential of such technology. Over the following decades, there were significant advances in computing technologies, leading to the development of more sophisticated devices with increasing immersion potential. The authors also highlighted that the great advance in virtual reality occurred recently, in the 2010s, with the launch of several devices by world-renowned brands, which brought this technology to large-scale consumption. Nowadays, it continues to evolve rapidly, especially in systems and equipment, seeking improvements in order to produce increasingly realistic simulations.

Mine (1995) explained that virtual reality tracks and synchronizes the movements performed by the user with the graphics displayed on the screens that are viewed, allowing the virtual reality to react to real actions, from the simple perception of being immersed in that environment to movement and interaction. with virtual objects. This interaction occurs through so-called direct manipulation techniques, which allow the user to use the movements performed by their body in the real world to cause changes in the virtual object (in the position, orientation or scale of the object, for example).

The term "user experience" was described in 1990 by Donald Norman with the purpose of better defining the degree of human experience when interacting with a product or software design (WOLCOTT et al., 2023). (GUERTIN-LAHOUD et al., 2023)

et al., 2023 demonstrated that User Experience has a positive, engaging and multisensory effect on users in virtual environments.

For De Faria et al. (2016), due to the nature of virtual reality, it could make anatomical teaching more efficient by allowing some setbacks of traditional teaching to be overcome.

Bergman, Van Der Vleuten and Scherpbier (2011) discussed how the traditional teaching of anatomy is based on the use of teaching tools, such as books and lectures, used for hundreds of years, and cadaveric dissections, which make up the gold standard of medical teaching. Currently, with the change in paradigms in education through the adoption of a new curriculum, there is a verticalization in anatomical teaching in such a way that learning is done in a progressive and fragmented way. Furthermore, part of the initial years of graduation, which were originally intended to understand the composition of the organism, are now dedicated to clinical applicability.

Although cadaveric dissection is the gold standard for teaching this discipline, it brings with it some disadvantages. The high cost of obtaining, maintaining and preserving; inadequate dissection/ conservation; anatomical variations; health and safety risks due to the toxicity of the compounds used in the conservation of specimens (DE FARIA et al., 2016); in addition to the emotional impact and personal reservations, mentioned by Araújo Júnior et al. (2020), represent some of the impasses generated by this teaching technique.

Campos et al. (2022) stated that characteristics inconsistent with those found

in a patient, such as appearance, smell and lack of movement; In addition to the short time to absorb the extensive and dense content, they also make the learning process difficult.

These disadvantages can be especially noticeable when teaching complex anatomical structures, such as the pelvis. Dietrich, Gehrich and Bakaya (2008) explained that this region is composed of an integrated network of muscles, ligaments, blood vessels and nerves that play a dynamic role in supporting the pelvic visceral organs, such as the bladder, uterus and rectum.

These organs are connected to the outside of the body through the urethra, vagina and anus, respectively. Functional homeostasis between these areas is crucial for the adequate physiological functioning of the organism, such as the maintenance of the urinary and fecal continence mechanism.

As expressed by Pandeva et al. (2019) and by Petros and Woodman (2007), due to the integration of this region, disturbances in any component can lead to symptoms that affect the reproductive, urinary or digestive systems, individually or together, complicating diagnosis and therapeutic management.

Dietrich, Gehrich and Bakaya (2008) also highlighted that these anatomical structures, due to their complexity, are not easily observable in routine gynecological procedures and often require evaluation through physiological or radiographic tests. Changes in pelvic floor anatomy can result in a variety of clinical presentations, including pelvic organ prolapse, urinary and fecal incontinence, and sexual dysfunctions.

According to Roch et al. (2021), up to 47% of women may present at least one pelvic disorder, highlighting the high prevalence of these problems in the female population. Therefore, knowledge of the structures of the female pelvis is essential, especially for the correct practice of surgery, which may be necessary in up to 20% of cases of pelvic disorders.

In this context, considering its complexity, Jeppson et al. (2018) stated that the anatomy of the pelvis has been the focus of debate for more than a century, with particularly controversial structures, which probably do not exist, being named, creating conflicts in the terminology present in the literature. This occurs mainly with connective tissue and muscles, as pointed out by Zhou et al. (2023), as surgeons from different areas name structures based on characteristics of their specialties, which makes standardization difficult and, according to Jeppson et al. (2018), results in a plurality of terms being used for the same structure such as the coexistence of the terms pubococcygeus muscle and pubovisceral muscle which refer to the same anatomical region.

Therefore, despite its relevance for the success of clinical and surgical practice in different areas of medicine, understanding the pelvic region is an arduous task, as, in addition to having multiple structures and presenting a complex physiology, there is a lot of contradictory information and conflicts. in nomina that confuse and make anatomical understanding difficult.

To be a good professional in medicine, it is necessary to have a deep knowledge of the human body in its physiological and pathological condition (ALMEIDA et al., 2022; NETO et al. 2020).

Based on the questions presented, Araújo Júnior et al. (2020) clarified that the use of virtual reality in teaching human anatomy in medical schools can overcome the obstacles to learning this discipline, including those generated by cadaveric use (DE FARIA et al., 2016), present since the Middle Ages (CALAZANS, 2013).

According to De Faria et al. (2016), this active methodology guarantees the safety and health of the student, as it does not

use chemical compounds; allows effective learning of pelvic dynamics through a high level of immersion with a high sense of reality without spatial and temporal restrictions; stimulates self-confidence, performance and understanding on the part of students (KIM; AHN, 2021).

Furthermore, this technology does not pose any risks to the integrity of the piece studied, because, as it is a virtual material, it avoids damage that, as Zielak and Deliberador (2011) showed, would inevitably occur in real pieces due to the manipulation of several students throughout the process. time.

However, Campos et al. (2022) highlighted that the advantages brought by dissection are maintained with the use of virtual reality, such as three-dimensional anatomy, which also solved the problem of two-dimensional images in books/PowerPoint (ZHAO et al., 2020); joint study (in pairs or groups) (LOSCO et al., 2017) and, as cited by McLachlan and Patten (2006), obtaining an essential basis for the study of other disciplines (such as physiology, microbiology and pharmacology).

According to Melo et al. (2007), virtual reality also provides a greater variety of structures, pathologies and particularities; makes it possible to repeat/redo training procedures without additional costs; assists in the development of skills, such as motor coordination, and promotes teamwork (MCLACHLAN; PATTEN, 2006). Furthermore, Parikh et al. (2004) highlighted that this innovation also allows the use of specific variations in the structures presented to make the experience more didactic or reliable, according to the purpose for which the tool was designed.

It was highlighted by Kim and Ahn (2021) that this method not only helps to overcome the disadvantages of dissection and maintain its advantages, as mentioned previously, but also provides student-centered learning through a highly immersive method and involving them in a adaptive system that makes it possible to evaluate your actions and simulate rare and dangerous cases, according to Diniz, Santos and Pessoa (2010).

For Stival, Ribeiro and Garbelini (2023), virtual reality also allows the training of technical skills, especially in surgical specialties; in addition to promoting a better distribution of medical resources, connecting medicine to technological advances.

Kim and Ahn (2021) also explained that, since medical education is often dependent on opportunities, even academics from the same institution and period have different teaching opportunities, in which it is unlikely that all students will be able to have contact practical with a specific case or unusual illnesses despite their relevance. In this sense, the teaching discrepancy could be curbed with the use of technological resources, such as virtual reality, promoting a more homogeneous academic experience and greater student confidence in carrying out procedures in clinical practice, with the advantage that ethical issues involving patient safety would be appeased.

Technology is increasingly part of our daily lives and reality, improving different methodologies in the teaching and learning process, being the language with which students have great affinity (COLARES et al., 2019). Therefore, Araújo Júnior et al. (2020) and Campos et al. (2022) highlighted that virtual reality can be a teaching tool to which students in the health field adapt more easily, consequently increasing the student's motivation and involvement in classes (KIM; AHN, 2021).

A survey carried out by Moro et al. (2021) indicated that students who used virtual reality as a learning tool defended its use, as well as augmented reality, stating that it is more enjoyable and that they become more committed to studying when using these

methods.

Because virtual reality provides greater satisfaction and makes the study experience more pleasurable, the relationship between its use and the learning outcome is positive. Factors such as student satisfaction, the sensory immersion provided by the equipment's characteristics, the intention to continue learning and the student's particularities have an influence of more than 60% on the learning outcome, as demonstrated by Kim and Ahn (2021).

Although the use of virtual reality began a few decades ago, Stival, Ribeiro and Garbelini (2023) highlighted that, with the Covid-19 pandemic, it became necessary to use new pedagogical methods to overcome social isolation. For this purpose, distance learning via digital platforms was widely used, a fact that accelerated the insertion of virtual reality in the academic environment as a learning tool, in order to complement remote teaching. In this situation, the use of virtual reality was fundamental because it included, in an interactive and contextualized way, people who would not previously have access to the content in person due to distance.

Studies recently carried out have demonstrated the great potential of virtual reality. De Moura et al. (2021) reported that the results obtained in most articles - in which the use of the active methodology was associated with technologies, such as virtual reality - were more effective than the use of the traditional methodology alone.

Even in articles that contradict this result, virtual reality still presents advantages, such as better performance compared to the traditional method in the long term, a positive impact on the perception of learning and how the experience of using the technology would be beneficial to patient care. (ELLINGTON et al., 2019; DE MOURA et al., 2021).

According to Zhao et al. (2020), around 60% of students obtained higher grades in tests administered using virtual reality compared to grades obtained with traditional teaching. However, as demonstrated in a study carried out by Stival, Ribeiro and Garbelini (2023), many articles avoid comparing virtual reality with dissection, as, in practice, both can be used simultaneously to better understand the pelvic region.

Diniz, Santos and Pessoa (2010) pointed out - regarding the use of virtual reality for teaching and training in gynecology - some benefits of using virtual simulators such as advances in individual and team performance.

This fact leads to a reduction in medical errors in real procedures, such as damage to underlying structures, which is pointed out as one of the main complaints made to the Medical Defense Union (MDU) against surgeons (ELLIS, 2002).

Furthermore, Parham et al. (2019) explained that criticisms of virtual reality are often based on arguments that its use would be too costly and that some users face physiological reactions such as dizziness and nausea when using the equipment.

Regarding the financial nature, it was clarified by Mathur (2015) that the use of virtual reality may not be as costly as believed, considering that there are efforts to develop this technology at a low cost aimed at medical teaching and, according to Parham et al. (2019), the acquisition of hardware and virtual reality glasses would cost less than USD $1500 and USD $399 respectively, a value that is relatively affordable when compared to the cost of acquiring and maintaining the cadaver: USD $8385 per cadaver. This amount excludes fees for building your own environment, maintenance costs, operation of the ventilation system, expenditure on human resources, among other expenses (SIMPSON, 2014).

Finally, regarding the discomfort that some

users may face, Parham et al. (2019) stated that virtual reality glasses are undergoing improvements that make them lighter to be used for a longer period of time, with the use of processors that synchronize human perception with the virtual environment, thus preventing disease. cybernetics.

To exemplify everything previously discussed, a demonstration was carried out using a functional pelvic anatomy teaching application through Virtual Reality.

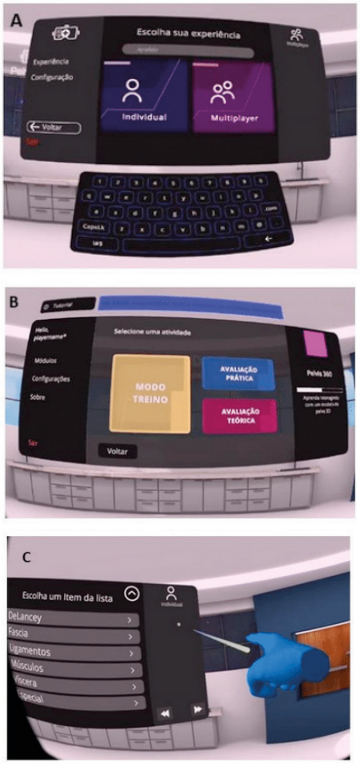

Figure 1 – Figure demonstrating the virtual environment encountered by the student. After entering the operating system through the virtual reality glasses, the user can select the individual or multiplayer experience (A). In this module, the student can also select the Training or Theoretical and Practical Assessment (B) modality. Having selected the training mode, the menu opens with the structures and concepts of the female pelvic anatomy, which can be selected for interaction (C).

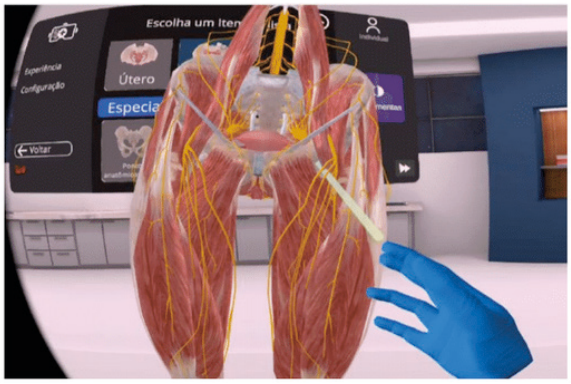

Figure 2 – Image demonstrating the virtual presence through an Avatar (blue hand), which corresponds in the real world to the device's controls (Joysticks). You can touch, hold and rotate the anatomical piece, as well as use the Laser Pointer function to name the structures under study.

Figure 3 – Image demonstrating the use of Virtual Reality in the Selflearning learning modality, where students follow the flow of their interest or a previously determined script to comply with the academic schedule.

Figure 4 – Image demonstrating the use of Virtual Reality in the "Master Class" Modality where the Teacher mirrors the content of his glasses and presents the sequential assembly of structures for many students to watch at the same time through the projection on a screen.

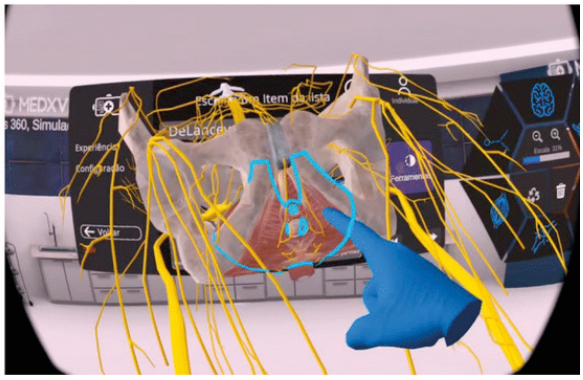

Figure 5 – Demonstration of a scene where the highlight of the structure can be presented by hatching the element under study. It is useful for learners who do not yet have anatomical knowledge and can identify it at a first glance.

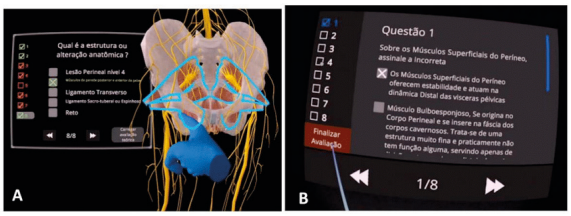

Figure 6 – Demonstration of the assessment environment. The teacher can apply a practical assessment, in which an anatomical piece is shown to the student, who must identify it (A) and can apply a theoretical assessment, in which a multiple-choice question is presented and the student must choose the best option (B)

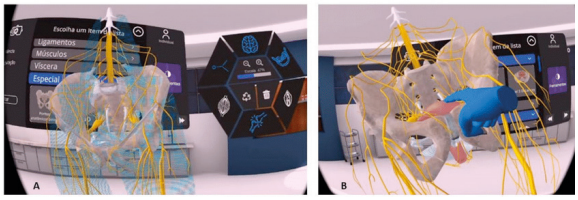

Figure 7 – Presentation of the virtual environment found by the student and how they can interact with the virtual anatomical pieces. By opacifying some elements to make others stand out, using a hexagonal interaction menu on the right (A) and manipulating the pieces with different configurations (B)

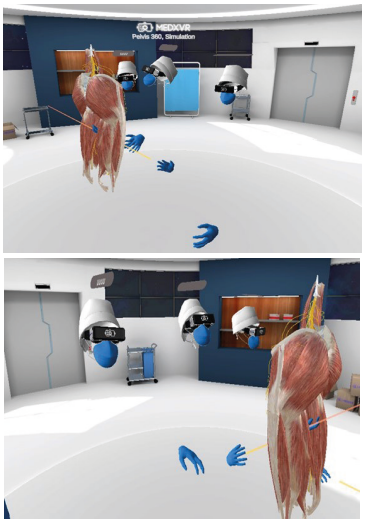

Figure 8 – Demonstration of the Metaverse room with 3 Avatars (users) who were in different cities, in the same virtual environment synchronously.

CONCLUSION

Virtual reality represents the evolution of medical education in the functional anatomy of the female pelvic floor. Considering all the challenges faced throughout history and the search for ways to acquire knowledge in this fundamental area for medical training, this technology emerges as an effective alternative, overcoming the limitations of traditional methods.

Through the simulation of anatomical structures in the virtual environment, the methodology provides an immersive, dynamic and interactive experience for the user, developing skills and abilities in a three-dimensional environment.

At the same time that it overcomes the disadvantages of traditional teaching, virtual reality is an excellent alternative technique and can be used in conjunction with other methodologies, in order to fill the gaps in education in the health area.

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