Review Article

Hueter-Volkmann Law; How It Influences the Correction of Scoliosis Curves with Braces?

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Abstract

Background: According to the Hueter-Volkmann law, there is asymmetry in the loads applied to the spinal structure on the convex and concave sides, which can increase the severity of scoliosis and its progression. The purpose of this review was to examine the asymmetry of vertebrae in subjects with scoliosis and explore how this theory can be utilized to enhance the effectiveness of braces in controlling and reducing scoliosis curves. A search was conducted in databases such as Google Scholar, PubMed, and ISI Web of Knowledge using keywords like Hueter-Volkmann law and asymmetry in relation to scoliosis. While there were limited studies on the asymmetry of vertebrae in individuals with scoliosis, the findings indicated significant differences in the height of vertebrae and discs between the concave and convex sides. Additionally, the degree of asymmetry was found to be correlated with the severity of scoliosis. It appears that the design of scoliotic braces is influenced by the Hueter-Volkmann law. It is recommended that new brace designs be developed based on the principles of this law to minimize the impact of gravity on the spine.

Keywords: Hueter-Volkmann Law; Asymmetry; Scoliosis; Braces

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Background

Scoliosis is defined as a three-dimensional deformity of the vertebral column, but it is mostly defined based on the lateral curvature of the spine (1). It is divided into idiopathic (unknown cause) and non-idiopathic (known cause) categories. Possible causes include genetic factors, growth abnormalities, hormonal dysfunction, changes in bone mineral density, tissue abnormalities in body parts, abnormal platelet calmodulin levels, biomechanical factors, and abnormalities in the central nervous system (CNS). The incidence of scoliosis varies between 2% and 13.6% (2-6). Depending on the severity of the deformity, various treatment approaches can be used for individuals with scoliosis, including conservative treatments and surgery. Some conservative treatments, such as the use of braces (Milwaukee, Boston, Wilmington, Lyons, Cheneau, etc.), exercise, and functional electrical stimulation, have been utilized (7). According to available literature, the use of braces can influence the progression of the scoliotic curve, but it does not impact the natural history of the curves (7-9). The effectiveness of the brace depends on the severity and location of the curve, as well as the age of the individual. Various configurations of transverse and vertical forces can be used in these braces to control the progression of the curve (10-15). Although the use of braces may control the progression of the scoliotic curve, it cannot reduce the curve. It is important to note that progressive postural skeletal growth deformities, such as scoliosis, are often attributed to the Hueter-Volkmann law, which states that bone growth depends on the mechanical loads applied to it (16). According to this theory, scoliotic curves experience greater loading on the concave side, leading to decreased bone growth, asymmetrical growth, and progression of the deformity. This asymmetrical growth can be observed in both vertebrae and disks (17).

The main question raised here is whether this theory is utilized in the design of braces for scoliosis. If the designs of the braces are based on this theory, why do the severities of scoliotic curves not significantly decrease after the use of braces? Therefore, the aim of this review was to examine the changes in the anthropometry of the vertebrae in individuals with scoliosis and to investigate the use of the Hueter-Volkmann law in the design of new braces.

A search was conducted in databases such as ISI Web of Science, PubMed, Google Scholar, and Scopus using keywords such as Hueter-Volkmann law and asymmetrical bone growth in relation to scoliosis. The initial criteria for selecting papers were based on titles and abstracts to address the research questions of interest. It is important to note that this review was narrative in nature; therefore, no quality assessment was performed in this study.

There are a limited number of studies on bone and disc asymmetry in individuals with scoliosis. Additionally, a few studies have explored the application of the Hueter-Volkmann law in correcting scoliosis curves. Some studies have discussed the effects of this theory in relation to night braces. In a study conducted by Mente et al., the effects of asymmetrical loading on vertebral growth were examined in a rat tail model. After 4 weeks, structural deformities were observed in the discs (18).

Another study by Scherrer et al. included 27 scoliotic subjects with mild to moderate Cobb angles (10-50 degrees). The results indicated that wedging was present in mild scoliosis and increased as the condition progressed. Another study demonstrated wedging deformities in the vertebrae and discs (17).

One of the theories that explains the progression of a scoliotic curve is the Hueter-Volkmann theory. According to this theory, vertebral bone growth on the concave and convex sides of the curve differs. Due to the asymmetry in applied forces on the convex and concave sides, the scoliotic curve increases over time. If the progression of a scoliotic curve is based on this theory, correcting the curve can only be achieved by changing the asymmetry of loading.

Although wearing a brace can stabilize and reduce the curve of scoliosis, it is not ultimately corrected. This may be because the curve is not completely corrected while wearing a brace, and there appears to be some asymmetry in the loads applied to the vertebrae even with braces.

It should be emphasized that this theory is also utilized in the design of night braces, such as Providence and Charleston bending braces (19-24). In the aforementioned braces, the effect of gravity is reduced, and gravity does not asymmetrically compress the vertebrae. Additionally, these braces promote overcorrection of the spine. However, the outcomes of this type of intervention are not the same as full-time brace wear (7). In most available full-time braces, the spine is subjected to asymmetric loading from gravity, weight, and muscle activity.

If the progression of scoliotic curves depends on Hueter-Volkmann's law, there should be some asymmetry in the height of vertebrae on the convex and concave sides of scoliosis. According to the literature, there is asymmetry in the height of vertebrae on the convex and concave sides of the disk and vertebra (16, 25). Furthermore, there is a correlation between the asymmetry of vertebrae and the severity of scoliosis. It is undeniable that reducing the asymmetry of vertebrae can potentially correct scoliosis curves. Moreover, the asymmetry of vertebrae is influenced by the loads applied to them. Therefore, it appears that greater correction of the scoliosis curve can be achieved by minimizing the effects of gravity and other compressive forces on the spine in standing and sitting postures. This can be accomplished through the proper design of spinal braces that alleviate the force of gravity on the spine in sitting and standing postures.

Conclusion

Based on the studies mentioned above, it can be concluded that asymmetrical loading applied to the spine may be an important factor in the progression of scoliosis. It is recommended that a new type of spinal brace be designed to alleviate the gravitational force on the spine in both sitting and standing positions.

Conflict of Interest

The authors declare no conflict of interest in this study.

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