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Technology and Sport at the Crossroads

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**Analysis of Jugular Compression Collars Preventing Concussions**

**Abstract:**

The jugular vein compression collar has been recently introduced into the world of sport. This collar causes physiological changes that lead to the impedance of concussions, by increasing the intracranial pressure making the brain more compressed inside the skull, producing an “air bag” effect to protect the brain from injury. This paper describes in detail how the collar works, as well as the advantages and possible dangers that can arise from wearing this collar. This collar has been tested in a wide variety of sports, like hockey, soccer, football, and even non-contact sports like track and field. The goal of this paper is to educate the reader about what a jugular vein compression collar does, and its effects on the user.

**Introduction/Background:**

Going as far back as Ancient Greece, helmets have always been ideal for head safety, while evolving with technology and variation over the years. Many people have tried to create a helmet that protects the user from brain injuries like concussions, but there is much more that goes into preventing those injuries than simply a cast for your skull. Though head protection has come a long way, now may be the time for a revolutionary advancement in the technology used for this purpose. The jugular vein compression (JVC) collar is a piece of equipment that is being used for the prevention of concussions. A concussion is formed when there is a force causing one’s head to jolt back (or forward) intensely, resulting in the brain hitting against the inside of the skull – which is the only part helmets protect. The JVC collar is worn on the back of the neck and compresses the jugular vein, increasing the intracranial pressure, and thus leading to a decrease in the amount of room your brain has to move around inside your skull. In this paper, we examine the methods, advantages and disadvantages of the jugular vein compression collar.

**Analysis:**

 When it comes to head injuries, many people look at the helmet as the best means of protection. However, the JVC collar approaches the problem from a different angle. This collar is the result of a large amount of research done on the exact effects of the “slosh” mechanism, a key process that largely influences these brain injuries. The slosh mechanism has been defined as “the oscillation of a fluid caused by external force,” (Smith et al., 2013). Studies have shown that by compressing the jugular vein in the back of the neck, it will cause an increase the amount of intracranial blood (blood volume inside one’s skull), thus decreasing the intensity of the “slosh”. By doing this, one source explains that “filling the compensatory reserve volume within the cranium is hypothesized to create a cradling effect that increases brain stiffness,” (Myer et al., 2016). This cradling effect is similar to an air bag system of a car, reducing movement by filling space. This idea originated from research showing the effects of altitude on the likeliness of sustaining a concussion. Higher altitude alters the compliance (stiffness) of the cranium, as observed when “increased DPG, red cell mass, intracranial volume, and decreased compliance (a ‘tight fit’), or a combination thereof, will mitigate *Slosh*,” (Smith et al., 2013). This is different than at lower temperatures because air not able to hold as much water. Accordingly, the JVC collar works as a result of compressing the jugular vein, while inspired by the effects of altitude.

There have been many studies conducted showing that the JVC collar prevents damage to the brain. Furthermore, there have even been findings that prove wearing the collar restores your brain to its initial structure. For example, in two similar studies testing the collar on high-school female soccer players and high school male football players, they found the brain changes in athletes not wearing the collar were more significant than in those wearing the collar. More specifically, the areas of the brain affected by the total amount of impacts resulting in the season were all associated with working memory. In each study, it was noted that “a significant pre- to post-season increase in fMRI blood oxygen level dependant (BOLD) signal was demonstrated when performing the (N-back) working memory task in the non-collar group,” (Yuan et al., 2017). The soccer study showed that despite the changes in the brain between the collar and non-collar group, the tasks performed only showed a slight deficiency in the non-collar group. That being said, the fMRI and task results didn’t line up as expected, however they also indicated that “the difference sometimes does not manifest unless participants with cognitive deficits are fully challenged to the limit of their capacity,” (Yuan et al., 2017). A major difference between the collar and non-collar groups was also in the neuronal activity when asked to perform tasks. Going off of testing limits, when a working memory task is performed, it is judged on the ability to complete the task and the brain’s activity level while performing it. Though completing the task may be effortless, the neuronal activity provided a major difference. After the season ended, it was found that they “would need to increase neuronal activity to accommodate the demand from the increase performance in that individual,” (Yuan et al., 2017). In other words, that individual would need to work harder for the same result.

For any injury prevention technology to work, it needs to be used by real people in the correct and accurate environment. Therefore, in addition to this collar preventing concussions, there is good feedback when it came to usability and tolerability when wearing it. A study was conducted resulting in the users liking the collar, saying they felt “an increased sense of protection,” (Feudtner et al., 2018), but also “little to no discomfort while wearing this device,” (Feudtner et al., 2018).

Though many of these sources discuss the pure advantage of the JVC collar preventing concussions, its dangers should also be considered. Compressing the jugular vein causes a number of risks as a result of all the physiological changes it causes to the body. For one, by compressing the jugular vein, it increases the intracranial pressure. This is the mechanism that creates the “air bag” for your brain. However, despite this positive side effect, there may be a point at which too much intracranial pressure is happening. In addition, there is a larger rate of blood flow within the brain. Whether this is a positive or negative side-effect is undetermined, though “the magnitude of the stiffening depends on the percentage of cranial blood draining through the internal jugular veins during compression,” (Hatt et al., 2015). This means that with a greater rate of blood flow (a greater PVLT), the stiffness of the brain inside the cranium also increases. However, there have never been any instances where one has experienced negative effects as a result of wearing the collar. Still, these precautions of wearing the JVC collar are important to know, and can in fact lead to negative side effects such as stroke or brain tumours.

**Discussion:**

This is a fairly new technology, and the number of studies examining this is not sufficient to confidently prove that the JVC collar is ultimately safe. Despite the prevention of concussions, the increased intracranial pressure may cause dangers as a long-term effect. For instance, if the user has a certain health condition, it could result in harmful consequences. High intracranial pressure causes changes in the physiology of the human body, and its risks are concerning. These developped symptoms include nausea, headaches, seizures, decreased alertness and vomiting, to name a few. These symptoms may be just as bad as sustaining a concussion itself, but it is only if the collar actually does produce enough long-term pressure in order to reach that state.

On the market, there is one specific type of collar, however it is not completely accessible. Bauer, the company that sells the *Neuroshield* (a spinoff of the JVC), only sells it in Canada, because they cannot yet confidently say it is safe. While the research shows all the positive feedback and results it’s attained, there still is that long-term question of whether or not it can be harmful to the user. Research should be taken to further degrees in order to determine the outcome, but despite the risk, it is an effective piece of preventative equipment.

**Conclusion:**

Despite the long-term dangers, the jugular vein compression collar can effectively prevent concussions, while being light-weight and tolerable by the user. Inspired by the physiological effects of altitude, this collar compresses the jugular veins, causing an increase of blood volume in the skull, and producing a higher intracranial pressure. This results in less room for the brain to slosh around, and therefore less chance of sustaining a concussion. However, the collar may produce too much intracranial pressure, potentially developing brain tumours or causing strokes, though there haven’t been any experiences of negative effects wearing the collar. Therefore, the jugular vein compression collar can be used to prevent concussions in sports and other areas of life.

**References:**

Smith, D. W., Myer, G. D., Currie, D. W., Comstock, R. D., Clark, J. F., & Bailes, J. E. (2013).

Altitude Modulates Concussion Incidence. *Orthopaedic Journal of Sports Medicine,1*(6), 232596711351158. doi:10.1177/2325967113511588

This study investigated the role that altitude plays in adjusting the pressure of intracranial fluid, resulting in the possible prevention of the likeliness of concussions. They were successful at proving high altitudes do in fact provide a “tighter fit” for the brain inside the skull.

Myer, G. D., Yuan, W., Foss, K. D., Smith, D., Altaye, M., Reches, A., . . . Krueger, D. (2016).

The Effects of External Jugular Compression Applied during Head Impact Exposure on Longitudinal Changes in Brain Neuroanatomical and Neurophysiological Biomarkers: A Preliminary Investigation. *Frontiers in Neurology,7*. doi:10.3389/fneur.2016.00074

This is a study of how a collar compressing the jugular vein can reduce the chance of sustaining a concussion. The collar works by applying this compression, which causes an increase in intracranial blood volume. This increase causes the brain to be less sloshed around in your skull upon impact.

Myer, G. D., Yuan, W., Foss, K. D., Thomas, S., Smith, D., Leach, J., . . . Altaye, M. (2016).

Analysis of head impact exposure and brain microstructure response in a season-long application of a jugular vein compression collar: A prospective, neuroimaging investigation in American football. *British Journal of Sports Medicine,50*(20), 1276-1285. doi:10.1136/bjsports-2016-096134

This study looks at the effects of a collar compressing the jugular vein on the reduction of concussions. It examines the effects it has on the brain by looking at certain diffusion tensor imaging techniques, from which three of them showed significant differences between collar- and non-collar –wearing athletes.

Yuan, W., Leach, J., Maloney, T., Altaye, M., Smith, D., Gubanich, P. J., . . . Myer, G. D.

(2017). Neck Collar with Mild Jugular Vein Compression Ameliorates Brain Activation Changes during a Working Memory Task after a Season of High School Football. *Journal of Neurotrauma, 34*(16), 2432-2444. doi:10.1089/neu.2016.4834

This study looks at the effects of the jugular vein-compressing collar on the working memory of the athletes studied. With the improvement that the collar ensues, there is an additional impact on the sustainment of working memory after a blow to the head.

Feudtner, C., & Miles, S. H. (2018). Traumatic Brain Injury News Reports and Participation in

High School Tackle Football. *JAMA Pediatrics*. doi:10.1001/jamapediatrics.2017.5242

This study simply looked at the use of the jugular vein-compressing collar on athletes wearing it for a longer amount of time. They look specifically at the comfort and mobility that the collar allows, concluding that it was completely fine to wear.

Hatt, A., Cheng, S., Tan, K., Sinkus, R., & Bilston, L. (2015). MR Elastography Can Be

Used to Measure Brain Stiffness Changes as a Result of Altered Cranial Venous Drainage During Jugular Compression. *American Journal of Neuroradiology,36*(10), 1971-1977. doi:10.3174/ajnr.a4361