

Helmet Design Matrix

Criteria (Weight)	Design #1: Airsoft Tactical Helmet		Design #2: Climbing Helmet		Design #3: Wrestling helmet	
						
	Raw Score	Weighted Score	Raw Score	Weighted Score	Raw Score	Weighted Score
Stability (40)	4.5/5	35	4/5	32	4/5	32
Durability (15)	5/5	15	4/5	12	3.5/5	10.5
Price (10)	4/5	8	4/5	8	4/5	8
Comfort (10)	3.5/5	7	3.5/5	7	5/5	10
Fit (10)	3/5	6	3/5	6	5/5	10
Ease of Use (10)	4/5	8	5/5	10	2/5	4
Total (100)	79		75		74.5	

Stability:

Stability of the helmet refers to how much the helmet limits independent movement between the helmet and the head as well as how securely it can mount the laryngoscope mount. This is crucial for the design of the helmet for continuous laryngoscopy during exercise (CLE) as independent movement of any component can result in poor video quality, inaccurate diagnoses, and patient discomfort [1][2].

The Airsoft Tactical helmet receives a 4.5/5 for its thick straps, multiple support axes, and hard, thick material. This helmet is rated slightly higher than the rest due to having both a hard shell and more adjustability. It has adjustable straps for both the vertical and horizontal directions, allowing for tightening in all directions. The thick and hard material can support the weight of the mount and laryngoscope with minimal deformations.

The climbing helmet receives a 4/5 due to its hard and thick helmet material but is behind the airsoft tactical helmet due to only having straps that can tighten in the vertical direction. The wrestling helmet receives a 4/5 for having straps that can tighten in all directions but its made of a softer material and thus the mount is not as well supported as the climbing or airsoft tactical helmet.

Durability:

Durability refers to how long the helmet will last and how it will physically respond to the nature of the CLE test. In order to measure durability multiple factors were taken into consideration, mainly material, flexibility, and typical shelf life. Material refers to both the inner and outer shells. A water-resistant shell will combat sweating from the CLE test, will tarnish less over time, and avoid issues such as mold. This category was measured by looking at manufacturing details and comparing different materials, flexibility of said materials, and researching shelf life of the average helmet. This assessment is important because this device should be reusable over a long period of time and a prominent part of this is how it will hold up and potential limitations provided by tarnishing.

Evaluating the durability of the tactical helmet revealed that it is the most durable. According to the selling website[3], it is made of ABS engineering plastic, foam, and nylon. Nylon is highly water resistant when combined with ABS engineering plastic, which is a large component to the longevity of the helmet. The average shelf life of an airsoft helmet is around 5-10 years [4]. In terms of flexibility, ABS engineering plastic has a slight bend[5] which will allow for more structure over time rather than repeated bending weakening the system. The tactical helmet also has straps that are one inch in diameter, providing a width that will allow for long use. Because of the hard plastic, large straps, relatively lightweight foam and nylon that repel moisture while still maintaining form, this helmet is the highest rated amongst all options.

Evaluating the durability of the climbing helmet revealed that it is the second most durable. According to the selling website[6], the helmet is constructed of foam liner similar to that of the tactical helmet and polycarbonate outer shell. As with the tactical helmet, the foam is lightweight and water resistant which will allow for no worry of mold growth or anything of that nature. The polycarbonate is also completely waterproof and a very hard exterior, which will allow for no bending and, therefore, no wear from bending. The drawback is the thinness of the straps. While almost every other aspect in terms of material is comparable to the tactical helmet, the straps are roughly 15mm wide[7], roughly half the size of those on the tactical helmet and the shelf life is typically 3-5 years if in use. These tinner straps will wear down quicker than those on the tactical helmet, resulting in the climbing ranking slightly lower.

Evaluating the durability of the wrestling helmet revealed that it is the least durable. According to the selling website, it is primarily a dense vinyl nitrile foam (VNF). This proves to be the least durable because it is a flexible material that is prone to wear and tear over time. VNF is not completely water resistant, unlike the other two helmets. While it is unlikely to grow mold, there is a slightly greater possibility than for the other helmets. The straps are about an inch wide, that is wider than the climbing helmet. When putting all factors together, it can be concluded that this is the least durable due to the slight potential for retaining moisture, high flexibility that can cause tearing down the line, one inch straps, and a shelf life from around 3 to 5 years.

Price:

Price refers to the total price of each helmet design possibility without including the prices of the materials used in the respective laryngoscope attachments.

The tactical helmet costs \$23.98. This is a cheaper, cost effective helmet option. The low price is why the tactile helmet has a score of 4/5.

The climbing helmet costs \$69.95, making it the second most expensive helmet option. The climbing helmet has a price score of 4/5.

The Wrestling helmet costs \$79.95. This low cost is why this helmet option has a score of 4/5.

Comfort:

Comfort refers to how pleasant the helmet feels when the patient puts it on for the duration of the CLE test. To evaluate comfort, many different considerations were taken but the level of padding, ventilation, and weight were deemed the primary factors. The level of padding refers to the amount of cushioning inside the helmet. A greater amount of padding aids patient comfort by distributing load pressure, conforming to the patient's head, and reducing friction inside the helmet. This category was evaluated by measuring/estimating the total area of cushioning inside each helmet. On the contrary, too much padding can lead to issues regarding ventilation or the expulsion of heat from the patient's head. Ventilation is important as during a CLE test, the patient will need to exert a very high exercise threshold leading to excess heat production. More open pathways, breathable pads, and helmet thickness all play an important role in maximizing the airflow and were evaluated for each design. Lastly, the weight of the helmet will increase strain on the patient's neck, causing additional stresses. Generally, a lower weight with a dispersed distribution reduces overall load to any specific muscle.

Evaluating the comfort of the airsoft tactical helmet showed that it excelled in padding but lacked in ventilation and weight. The airsoft helmet features a foam inner lining, providing effective cushioning and conformity for any given patient. The foam inner lining is relatively breathable due to its low density, however the hard exterior shell would trap much of the produced heat. Lastly, the tactical helmet would also be the heaviest of all three designs. This is due to its heavy-duty nature, built for protection, stability using many straps, and attachment areas. The total weight comes out to be 0.73 kg.

Evaluating the comfort of the climbing helmet produced showed moderate padding, poor breathability, and a moderate weight. The inner lining of the helmet is made of EPS foam, a type of foam meant for shock absorption rather than comfort but can still mold effectively. The breathability of EPS foam is very poor. In combination with the rigid outer shell, the helmet has very low breathability despite its ventilation pockets. Lastly, the helmet weighs 0.36 kg, half the weight of the tactical helmet and does not feature any unnecessary mass.

Evaluating the comfort of the wrestling helmet by far produced the best results. The wrestling helmet is made by a mixture of *LeaderHeadgear's Contek* and *Popfoam* material, primarily composed of EVA foam. EVA

foam is a lightweight, low density, springy material that excels in providing adequate cushioning in most sports equipment. The wrestling helmet features many open spots that allow for ventilation; Additionally, EVA foam is highly breathable and does not absorb water or sweat. Though an exact weight value is not specified in the product description, the helmet is advertised as “lightweight” and doesn’t feature any solid components, rather just foam and straps. The weight can be assumed to be much lighter than both the tactical airsoft and climbing helmets.

Summary of comfort findings for each helmet:

Helmet:	Tactical Airsoft	Climbing	Wrestling
Padding	Excellent	Moderate	Excellent
Ventilation	Poor	Poor	Excellent
Weight	Poor	Moderate	Excellent

Fit:

Fit refers to the helmet’s ability to properly fit a range of patient head sizes and is directly tied to both comfort and stability. Helmets were ranked on fit primarily on their adjustability to accommodate different head sizes. It is worth noting that two helmets of different sizes can be bought as an alternative to a single helmet with high adjustability. Price and mount attachment considerations would dictate this option.

The tactical helmet received a 3/5 for fit because while adjustable, the adjustments do not account for the full range of head sizes the design aims to accommodate. The helmet is rated to fit head circumference between 55 and 60cm, or about half of the 53cm to 63cm goal. Two or even three helmets would likely have to be purchased, or extra foam padding and/or straps would have to be added to ensure proper fit. The chin straps are adjustable to suit nearly all head heights.

The climbing helmet received a 3/5 for fit also for the same reason. The adjustable occipital dial only accommodates head circumferences between 58.4 and 63.5 cm, which again does not accommodate the target the design aims for. Two or even three helmets would likely have to be purchased, or extra foam padding and/or straps would have to be added to ensure proper fit. As with the tactical helmet, the chin straps are adjustable to suit nearly all head heights.

The wrestling helmet received a 5/5 for fit due to its high level of adjustability and large, secure chin strap. The helmet has several velcro straps and is made of hard EVA foam, which allows for a comfortable, form fit to each patient’s head. A single wrestling helmet would accommodate the goal range of 53 to 63cm head circumferences.

Ease of use: how easy mount fit and how easy it is to put on the head and how easy it is to put the scope on.

Ease of use refers to how easily the helmet can be prepared and operated in continuous laryngoscopy tests. This includes how easy it is to install onto the helmet, how easy the helmet can be placed on the patient's head, and how easy it is for the laryngoscope to be put on. Designs that require fewer steps or complications would score higher in this category.

The Climbing helmet receive a 5/5 in ease of use because it have simple adjustment system that can be quickly place and secure on the patient, and the dial in the back would allow the helmet to be tightened or loosened with a single adjustment, while the chin strap provides additional securement to prevent slippage. The rigid outer shell also provides an easier installation of the laryngoscope mount. Overall, the relatively small number of adjustment steps makes it easier to prepare the helmet and attach the mount for testing.

The tactical airsoft helmet received a 4/5 in ease of use because of its rigid outer shell and the pre-build attachment are provides a more suitable structure for securing and installing the mount. However, the helmet contains more straps and adjustment components than the climbing helmet, requiring additional step to properly fit and secure onto the patient's head. The helmet is designed with multiple straps to improve stability, however, these additional components can increase setup time. Therefore the helmet would still be relatively straightforward to use, as it was ranked slightly below climbing helmet.

The wrestling helmet received a 2/5 for ease of use because it relies on several velcro straps and a large chin strap that must be individually positioned and adjusted to obtain fit. In addition its flexible foam material provides a less rigid surface area for attachment of the mount, which makes installation and positioning of the mount system more difficult. Because there are more adjustable and positioning required before attaching the laryngoscope, the wrestling helmet receives the lowest ease of use score.

References:

- [1] P. Yao, D. Witte, H. Gimonet, A. German, K. Andreadis, M. Cheng, L. Sulica, O. Elemento, J. Barnes, and A. Rameau, “Automatic classification of informative laryngoscopic images using deep learning,” *Laryngoscope Investigative Otolaryngology*, vol. 7, no. 2, pp. 460–466, 2022. [Online]. Available: <https://pmc.ncbi.nlm.nih.gov/articles/PMC9008155/>
- [2] Z. Fretheim-Kelly, T. Halvorsen, J.-H. Heimdal, E. Strand, M. Vollsæter, H. Clemm, and O. Røksund, “Feasibility and tolerability of measuring translaryngeal pressure during exercise,” *The Laryngoscope*, vol. 129, no. 12, pp. 2748–2753, Dec. 2019. [Online]. Available: <https://pmc.ncbi.nlm.nih.gov/articles/PMC6900056/>
- [3] GWEUZMALL, “MICH 2000 Airsoft Helmet, with Side Rails and NVG Mounts for Outdoor Activities Such As Airsoft,” *Amazon.com*. [Online]. Available: <https://www.amazon.com/dp/B0FWBSV65P>. [Accessed: Sep. 29, 2026].
- [4] N. Duelund, “Do ballistic helmets expire? Understanding ballistic helmet expiration & lifespan,” *Protection Group Denmark*, Aug. 18, 2025. [Online]. Available: <https://protectiongroupdenmark.us/blog/do-ballistic-helmets-expire-understand-helmet-lifespan-and-when-to-replace-them/>. [Accessed: Sep. 29, 2026].
- [5] Laszeray Technology, “A comprehensive look at ABS in plastic injection molding,” *Laszeray Technology*. [Online]. Available: <https://laszeray.com/a-comprehensive-look-at-abs-in-plastic-injection-molding/>. [Accessed: Sep. 29, 2026].
- [6] Backcountry, “Black Diamond Half Dome Helmet,” *Backcountry.com*. [Online]. Available: <https://www.backcountry.com/black-diamond-half-dome-helmet>. [Accessed: Sep. 29, 2026].
- [7] A. Bikulov, “EN 12492 & UIAA 106 standards for climbing and mountaineering helmets,” *Bikulov.net*, Aug. 2024. [Online]. Available: <https://bikulov.net/climbing-helmet-standards>. [Accessed: Sep. 29, 2026].