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Analysis of the Military Attributes Selection Based on Ergonomic Aspects in the Indonesian National Armed Forces

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ABSTRACT: This paper presents a summary of several studies on the use of ergonomics in the military. The purpose of this research was to analyze the value of ergonomics in the military field. To collect, identify, and evaluate problems in the military field, this study used a literature review study method. The data used in this study were secondary data sources. The relevant journals as the research data were obtained from Google Scholar and Scopus. "The application of ergonomics in the military field" was the keyword used in the article search. The review showed that ergonomics issues in the military field were important to apply to overcome the soldiers that may become easily tired and uncomfortable when wearing the clothes. This review concludes that the application of ergonomics in the military field by paying attention to the design of the related clothing is very important.

Keywords: Ergonomics, Military, Clothing

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1. INTRODUCTION

The military is the armed forces of a country with all its links. The military is also referred to as an army that has a very sacred and noble task to defend the territory or state sovereignty [1]. A series of noble tasks require a military who has theoretical and practical skills in the science of warfare/combat. Good infrastructure for training greatly affects military skills in carrying out their duties. Thus, parties who intend to disrupt the integrity of territorial sovereignty will feel afraid because they are unable to fight the TNI, which is solid, compact, and loyal in guarding the Unitary State of the Republic of Indonesia.

This role of the TNI in maintaining the integrity of the Republic of Indonesia is unquestionable. The TNI has repeatedly proven that it can carry out its duties properly whenever a threat arises that can divide the unity and integrity of the nation, both from outside and from within. Therefore, every child of the nation is expected by the government to be able to contribute and share ideas, works, and others in the context of TNI independence, especially in terms of defense equipment and supporting equipment [2].

Ergonomics and comfort are certain things that must be considered before designing all components of military attributes. To produce a good design of attributes and according to needs, it is necessary to recognize the characteristics, limitations, and abilities of humans. This is because humans have a central role as planners, designers, implementers, and evaluators of work systems that work as a whole to obtain satisfactory results. The science that studies humans and their behavior in work systems is called ergonomics [3].

Based on this description, this paper examines the analysis of the selection of military attributes based on ergonomic aspects of the Indonesian National Army which aims to improve the quality and comfort of the attributes used by the Indonesian National Armed Forces through literature studies in the last ten years.

2. RESEARCH METHODS

The methodology used in this study was a literature review using articles from Google Scholar and Scopus. Journals that were accredited by ISSN and published within the last five years were used as criteria. There were 30 national and international journals used in this study. Google Scholar was used to conducting the search, which included the keywords "ergonomics applications in the military field." Another method used was to compare this study to previous studies on the subject of ergonomics in the military.

3. RESULTS AND DISCUSSION

From a search of national and international journals related to the design of military attributes with ergonomic aspects, 30 journals were obtained from various sources of accredited publishers. The journal sources that have been selected were then analyzed and examined to determine the selection of military attributes with ergonomic aspects.

Table 1. Journal of Ergonomics Applications in Military Field

No	Journal's Title	Publication	No	Journal's Title	Publication
1	Desain Rompi Serbu Ergonomis Untuk Prajurit Infanteri TNI-AD dengan Konsep Modular [4]	ITS Repository	16	Insoles of Uniform Softer Material Reduced Plantar Pressure Compared to Dual-Material Insoles During Regular and Loaded Gait [5]	Elsevier
2	Designing Passengers Cabin of Carrier Vehicles of 6x6 Armour Personnel with Principles of Ergonomic [6]	Elsevier	17	Penentuan Jarak Optimal Antara Helm dan Kepala dari Sudut Pandang Kenyamanan Thermal pada Helm Tentara [7]	UGM Repository
3	The Ergonomics Design of The Military Backpack for Indonesian National Soldiers Using Virtual Environment Model [8]	Elsevier	18	Effects of Body Armor Fit on Encumbered Anthropometry Relative to Bulk and Coverage, International Conference on Applied Human Factors and Ergonomics [9]	Elsevier
4	Analisis Ergonomi pada Desain Kursi Personel Kendaraan Tempur Lapis Baja dalam Antisipasi Dampak Terkena Ranjau [10]	Indonesian Design Journal	19	Prediction of Military Combat Clothing Size Using Decision Trees And 3D Body Scan Data [11]	Elsevier
5	Pengukuran Kelelahan Otot Punggung Pada Tentara Nasional Indonesia [12]	Journal of Engineering and Technology	20	Influence of Military Workload and Footwear on Static and Dynamic Balance Performance [13]	Elsevier

6	Desain Sepatu Lapangan Pasukan Infanteri TNI AD [14]	ITS Repository	21	The Effects of Mass, Bulk and Stiffness of Personal Protective Equipment and Clothing On Physical Performance When Performing a Military Mobility Obstacle Course [15]	Elsevier
7	Komparasi Kualitas Loreng TNI Terhadap NATO Berbasis Standar Nasional Indonesia [2]	National Seminar on Technology and Engineering (SENTRA) 2019	22	Effects from Loaded Walking with Polyurethane and Styrene-Butadiene Rubber Midsole Military Boots on Kinematics and External Forces: a Statistical Parametric Mapping Analysis [16]	Elsevier
8	Effects of Modern Military Backpack Loads on Walking Speed and Cardiometabolic Responses of US Army Soldiers [17]	Elsevier	23	Cluster Size Prediction for Military Clothing Using 3D Body Scan Data [18]	Elsevier
9	The Effect of an Optimised Helmet Fit on Neck Load And Neck Pain During Military Helicopter Flights [19]	Elsevier	24	Impact of Military Type Footwear and Workload on Heel Contact Dynamics During Slip Events [20]	Elsevier
10	Analisa Kekuatan dan Ketahanan Luntur Kain Loreng Singlecam X-01 Berbasis Standar Nasional Indonesia [21]	Technical Development 13	25	Perancangan Awal Pengembangan Disain Kain Loreng Loreng Militer Motif Hutan Semak [1]	Journal of Energy Conversion and Manufacturing UNJ
11	Uji Kualitas Kain Loreng Militer Pixel Design Berbasis SNI-ISO [22]	Jurnal Ilmiah Giga	26	Studi Perbandingan Ketahanan Luntur Warna Pencapan Kain Loreng British A 35% P/65% C dengan Zat Warna Campuran [23]	Technical Development 13
12	Identifying Problems that Female Soldiers Experience with Current-Issue Body Armour [24]	Elsevier	27	Hubungan Penggunaan Jangka Panjang Sepatu Militer Pada Prajurit Batalyon Infanteri TNI-AD Terhadap Angka Kejadian Flatfoot Di Lingkungan KODAM IV/Diponegoro [25]	UGM Repository

13	Evaluating Tactility and Dexterity for Military Aviation Protective Gloves [26]	Journal Indexing and Metrics	28	Development of a Military Helmet Using Coconut Fiber Reinforced Polymer Matrix Composite [27]	European Journal of Engineering and Technology
14	Sizing System Rompi Anti-Peluru untuk Personel Tentara Nasional Indonesia [28]	DSpace UII	29	An Analysis of Body Armor Sizing and The Development of an Existing Sizing System for the Indonesian National Army [29]	Engineering Letters
15	Evaluation of blunt impact protection in a military helmet designed to offer blunt & ballistic impact protection [30]	Elsevier	30	Ballistic Testing of ThyssenKrupp Steel Europe Armor Steel in Accordance with U.S. Military Armor Specifications [31]	Proceedings of 26th International Symposium on Ballistics

Many problems are found in military attributes in terms of ergonomics. Alan [4] emphasized the importance of prioritizing comfort when designing an assault vest for TNI-AD soldiers when carrying out missions in the field of operation. The Assault Vest in this case features modular pockets and components that allow the soldier to customize and modify the pouch himself according to the needs when used in the field of operation and the duration of a particular mission. One other study related to the attributes of army clothing was conducted by Setyawan et al [1] that tested the strength and quality of army cloth by comparing several cloths.

The research of Melia et al [5], considers the insole material to be used in military uniforms. The study found that backpack weight significantly increased peak plantar pressure during walking with and without soles on. The more insoles used, the more effective it will be to reduce back foot pain and forefoot plantar pressure by increasing the contact area of the midfoot compared to rigid composites in the dual material sole. Therefore, soft polyurethane material is recommended for use as an insole as it is designed to reduce plantar stresses in regular gait and loads up to 10% of body weight. Alan's research [14] creates an ergonomic and functional field shoe design that can adapt to the terrain and natural conditions in Indonesia. Research by Hunter et al [13] on the other hand, conducted an assessment of the impact of two military footwear, namely standard (STD) and minimalist (MIN) boots on human balance before (PRE) and after (POST) military-type simulations such as weightlifting exercises. The study found that boot design characteristics may have had a greater influence on the left foot and revealed significantly greater postural sway in the STD boot and under POST workload conditions. Decreased balance can be attributed to boot design characteristics and workload exertion. A similar study was also conducted by Mulya [25] where the study evaluated the incidence of flatfoot in a population of infantry soldiers who used military boots.

Research De Souza et al [16] was a study that aimed to determine the effect of military boot design on muscle fatigue experienced by soldiers. The methods used were SPM and ANOVA. The conclusion was that the SBR boot state presented a lower GRF at the start of the stance with a lower instantaneous loading rate and median frequency than PU. These results indicated better impact absorption for the SBR of the boot material without interaction with the load. GRF is sensitive to footwear and the effects of load, while load carrying increases trunk, hip, and knee arches. Studies showed that manufacturers should also consider midsole hardness when optimizing military boot performance. Military footwear design should focus on characteristics that minimize impact and allow for consistent lower extremity kinematics, allowing the user to perform operations more safely with fewer energy costs and muscle fatigue. Another study related to the attributes of military boots was Chander et al [20] which aimed to analyze the impact of two military boots, standard boot (STD) and minimalist boot (MIN) on slip events, before (PRE) and after (POST) military-type loads while

performing tasks. The result of this study was the need to consider extrinsic factors such as footwear design and intrinsic factors such as muscle fatigue. Both of these factors are considered very important to understand the risk of slipping and falling while carrying out military duties so that military personnel can carry out operations safely.

The insole material is considered by Melia et al [5] to be suitable for military uniforms. When walking with and without soles on, backpack loads significantly increase peak plantar pressure. The more insoles used, the more effective it will be in reducing back foot pain and forefoot plantar pressure by increasing the contact area of the midfoot compared to rigid composites in dual material soles. As a result, a soft polyurethane insole designed to reduce plantar stresses in regular gait and loads up to 10% of body weight is recommended for use as an insole. Looney et al [17] evaluated the effect of load carried in a recently developed military backpack on walking speed and cardiometabolic responses of dismounted warriors and found similar results. Even in the most recently designed load cars of equipment, Warfighters experienced a significant reduction in walking speed with a concomitant increase in physiological strain while carrying increasingly heavier loads, according to the findings of this study. The decrease in performance was accompanied by a non-linear increase in VO2 and a significant increase in HR.
Van den et al [19] investigated the effect of improved helmet fit on experienced helmet stability (gliding helmet), neck load, neck pain, hot spots (pressure points), irritation/distraction, and helmet comfort on military helicopter crew members during the night flights. The neck pain experienced with an optimized helmet fit is strongly related to the neck load experienced during flight, according to this study. An optimized helmet fit increases helmet stability, reduces neck load and hot spots, and improves overall helmet comfort during helicopter flights. There were fewer hot spots and a higher overall perceived helmet comfort level at night, both of which were strongly associated with flight irritation/annoyance. These findings highlight the importance of designing optimized helmets for military helicopter crews, as well as the fact that a better helmet fit may have implications for both health and safety concerns. According to Nugroho et al [7] a study on the ergonomic distance between the helmet and the head on a military helmet was developed to meet the needs of ergonomics. The results showed that when considering the velocity of the air in the cavity, the temperature, and the mole fraction of H2O, a distance of 0.9 cm is optimal. Thus, when deciding on a helmet design, efforts should be made to improve the quality and ergonomics of military helmets by taking thermal comfort into account.

Rudi et al [12] explained that the purpose of the study was to measure the level of fatigue experienced by the Indonesian national army during training by referring to ergonomically determined rules to avoid injury. Overall, studies have shown that more than 92% of the body parts submitted in the questionnaire assessment are painful and require immediate repair. Based on various journals related to military attributes in terms of ergonomics, it can be seen that ergonomics in the military world is indeed something that must be considered and applied so that the military work tasks of a soldier can be carried out optimally.

4. CONCLUSION

Ergonomics aspects play an important role in all aspects of life, including military attributes. Helmets, uniforms, bullet-proof vests, shoes, bags, and other military equipment must be meticulously detailed to be comfortable and ergonomic. This paper is a summary of several national and international journals on the relationship between military ergonomics and comfort and the quality, size, and selection of military attribute materials. The results found that more than 60% of the ergonomics of the attributes are mandatory for military attributes. Military attributes that are ergonomic and comfortable can improve comfort in combat and all other military activities, increasing military focus and agility in all activities.

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