

Review Article

Exercise training in polluted environment: A narrative review with focus on combat physical fitness

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Abstract

Air pollution is one of the most important problems of recent decades, which has serious toxic effects on human health and the environment. Sources of pollution vary from small units of cigarettes and natural sources such as volcanic activity to large volumes of emissions from car engines and industrial activities or even radioactive ones. Today, there are various pollutants around the world that negatively affect human health. Walking and being in a polluted environment can increase the penetration of pollutants such as lead in the body. Increasing physical activity such as long-term running, which is widely used in some jobs such as military jobs, can increase the activity of muscle tissue, and as a result, the cardiovascular system becomes more active and helps absorb more pollutants. Lead acetate is a possible carcinogen in humans, which is absorbed into the human body by pollutants. There is evidence that lead compounds can cause lung, brain, stomach, and kidney cancer in humans. However, pollution does not include air pollution only, and noise pollution can endanger human health as well. Since some occupations such as those of military experience various types of noise, as well as chemical and radioactive pollution and the point that having high physical fitness is essential for these people, this study examined the impact of various pollutants on the military personnel and also sought to see whether exercising and having high physical fitness of military personnel can reduce the stress caused by the pollution.

Key Words: Exercise training, Muscle tissue, Pollution, Military, Physical fitness

Introduction

General combat readiness is a set of preparations that include the health, readiness and resilience of troops so that they can cope with challenges and survive against threats (Mullen, 2010). General combat readiness is defined in eight areas of nutritional, medical, environmental, physical, social, spiritual, behavioral, and psychological readiness (Fig 1). Environmental readiness is defined as one of the abilities related to the execution of special missions in environments and survival in the face of various stressors such as maneuvers and war. Most of the stressors can be detected, measured and adjusted before the operation. These factors are generally divided based on physical, chemical and biological characteristics and include cold, altitude, ionizing radiation, and noise. Chemicals include fine processed particles, biological agents in food, water, and other substances. moreover, stressors can be considered in three categories: physical (such as temperature, noise, altitude), biological (such as food, water and diseases caused by biological vectors), or chemical (such as environmental and occupational pollutants) (Lounsbury et al., 2003).

Modulation of these stressors can improve environmental preparedness and reduce their associated risks to military forces. However, quantitative measurement of some of these cases and their combined effect has been difficult, and this is one of the challenges that may not be fully recognized and adjusted before the maneuver. In addition, it is likely that training for one particular environment may limit applicability in another environment. It should be considered that these stressful factors are different for each rank, as it has been stated that for the air force, these factors include temperature, noise, altitude, chemicals and work environment (Shih et al., 2015b).

The most key factors to increase the resilience of military personnel in unusual environmental conditions include prevention of exposure to stressful factors and environmental threats, and in the next stage, protection against these factors and threats. Self-prevention is related to safety culture, safety exercises and training, financial incentives to prevent injury, and

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Figure 1. Total force fitness domains (Jonas et al., 2010)

the definition of standards and laws. Preventive measures such as the use of personal protective equipment (such as masks), adaptation to the environment and acceptance of the environment and considerations which are ergonomic. While adaptation to the environment can reduce the negative effects of some environmental stressors such as temperature and altitude (Shih et al., 2015b), there is limited information about other environmental stressors such as chemical and nuclear contaminated environments. The concentration of many pollutants such as suspended particles, 2SO, 3O, metals and benzene is usually higher in the open air and some pollutants include carbon monoxide (CO), 2NO, some aromatic hydrocarbons and many volatile organic compounds such as toluene, xylenes, formaldehyde and chlorinated methane have a higher concentration in closed spaces (Turner et al., 2020).

Chen et al. (2019) showed that long-term exposure to urban PM_{2.5} is associated with reduced skeletal muscle mass and increased body fat mass among healthy elderly living in Taipei Basin, where the annual average of PM_{2.5} concentrations is much higher than the regulated levels suggested by the World Health Organization and where traffic emission is the main source of ambient fine particles. Physical activity ameliorates the detrimental effect of PM_{2.5} on skeletal muscle mass and body fat mass. As a result, doing exercise training, especially in the military, which is exposed to various types of pollutants, can be considered as a risk factor reducer, and was considered in this study.

Radioactive contamination

For the first time in the world, Uranium was released in Iraq and

in the military operation called "Desert Storm". It was widely used and presented as a pollutant risk for the environment, which affected both the residents in the contaminated areas of the war zone and soldiers (Faa et al., 2018). Nwaedozie et al. studied the environmental effects of lead, copper, chromium, zinc, manganese and nickel toxic metals and concluded that military training areas are contaminated with these trace metals (Nwaedozie et al., 2013). Limited studies have been done so far regarding the effect of exercise and muscle contraction on the control of radioactive damage. It seems that doing exercise training, especially resistance, by increasing muscle contraction and producing some secretoms such as irisin can control the damage of these substances on the body to some extent. Therefore, it is suggested that military forces should also perform resistance sports exercises.

Noise pollution

Long-term exposure to sound above 85 decibels (db) can lead to permanent hearing loss. If you are exposed to higher levels of sound even for a few hours a day, it can lead to hearing damage. Another hearing problem that occurs for personnel is the rupture of the eardrum caused by the explosion and the justification caused by the explosion (Ritenour et al., 2008). Exposure to noise pollution can be reduced with engineering controls (such as soundproofing systems), management controls (such as keeping personnel away from the noise pollution environment) and hearing protection devices (HPDs). However, in the military forces, the equipment is less acceptable due to their inconvenience and communication problems when using them. In addition, for good performance, HPD should be completely suitable with the physics and ergonomics of the personnel. In military forces and in situations where they need to wear their own helmets and breathing masks, the convenient use of hearing protection devices is limited, although there is a need to protect against noise pollution in these situations (Shih et al., 2015a).

Military forces with more years of service had more problems with hearing loss, as 25% of military forces with a history of more than 17 years experienced hearing loss, while this rate was 5% in personnel with less than three years of service (Kelley, 2003). Since 2011, with the reporting of hearing problems cases in the forces of Iraq in the US Army, it has led to the requirement not to send soldiers who did not have the proper hearing preparation. These listening standards make the need for modern audio recording devices and military earphones and the audio recording devices increased from 168 thousand in 2003 to 440 thousand in 2006 in the US Army (Shih et al., 2015b).

The sound of weapons, airplanes, and other military equipment with high noise pollution can play a significant role in reducing hearing power. However, some military forces do not use hearing protection devices in emergency situations because they do not

fit with their helmets or breathing masks. Unlike other stressors, sound is one of the risks whose prevention is not prioritized over adapting to environmental conditions or tolerating it. Therefore, in the case of noise pollution, physical preparation cannot be considered as the first priority, but not being exposed to risk and having appropriate equipment such as special protective phones in missions and environments with more noise pollution than 85 dB are suggested (Shih et al., 2015b). In addition, it is suggested that in order to protect the military forces exposed to this stressful factor from noise pollution, the equipment should be designed and made according to their helmets and masks and the organizational missions of these forces, so that these people can easily use these devices with other equipment and tools and even during missions that require intense physical activity.

Chemicals

The maximum allowed amount of petrochemical products in room air during 8 working hours per day or 40 hours per week is 400 mg per square meter. The fuel used in jet airplanes is propellant (JP), which has a low risk of medium-term exposure to three milligrams per square meter of this substance. A person's ability to withstand and work in a chemical pollution environment depends on the level of pollution, body tolerance and the level of toxicity of chemical substances. Some people may absorb chemicals quickly and process them quickly and eliminate them efficiently while other people are susceptible to the negative effects of these substances due to underlying health diseases (Shih et al., 2015b).

High-risk work environments

Work environments can be dangerous not only for military personnel, but also in the community for some occupations (such as nurses, truck drivers, construction workers, and police officers) who work outdoors are exposed to potentially dangerous environments in the period of employment. One of the ways to detect the level of risk of stressful work environments is to pay attention to the injuries and deaths related to that job.

Adaptation to the environment is an adaptive process that reduces physiological pressures caused by persistent environmental stresses. Tolerance is the result of adaptation to the environment at the cellular level, by which a person protects himself against environmental stressors. Interactive tolerance occurs when a person's exposure to a stressor leads to tolerance of another new environmental stressor. However, it is difficult to measure how much a person has adapted to an environment. An easy way to measure adaptation to a stressor is to simply ask the individual how comfortable they are in these particular conditions, such as heat and altitude (Hellon et al., 1956).

Unfortunately, the subjective measurement of comfort and stress

is very unreliable. Adaptation indicators are focused on biochemical and cellular markers, to what extent the function of cells is adapted to heat conditions (Horowitz, 2007) or to what extent they can tolerate altitude (Murray, 2009). However, these measurements are expensive and there are problems to collect data in the real environment outside the laboratory environment (Shih et al., 2015b). Therefore, it seems that having laboratory equipment in simulated environments with a battle scene and sending troops to battle can more objectively show the adaptability to different environmental conditions and the tolerance of troops.

Conclusion

Adaptation to the environment is one of the factors of environmental readiness and it means that the military has the knowledge, skills and appropriate behavior to protect themselves against stressful environments. In general, environmental preparedness is classified in two levels: prevention of exposure to danger and environmental threats and protection against threats and stressors in the environment. Preventive measures include promotion of safety culture, safety exercises and training, financial incentives to prevent injury, and establishing safety rules. In this regard, managers' commitment to safety is particularly important.

Protective measures include the use of personal protective equipment, environmental compatibility and tolerance, and ergonomics. It seems that the role of physical fitness in combat in the stage of protective measures to improve the ability to adapt to different environmental conditions is stronger than the preventive role, however, there is limited research on adaptation to heat and altitude conditions in the forces. Therefore, there is a need for cohort studies in different environmental conditions such as the sea and pollution to clarify the issue.

What is already known on this subject?

Air pollution is one of the most important problems of recent decades, which has serious toxic effects on human health and the environment.

What this study adds?

Adaptation to the environment is one of the factors of environmental readiness and it means that the military has the knowledge, skills and appropriate behavior to protect themselves against stressful environments.

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