Original Article

Factors Associated with Heat Related Illnesses among Soldiers: A Systematic Review

Deepreecha K, MD, MSc[1], Buranatrevedh S, MD, MPH, DrPH[2]

[1] Health Promotion and Preventive Medicine division, Royal Thai Army Medical Department, Bangkok, Thailand
[2] Department of Community and Family Medicine, Thammasat University, Pathumthani, Thailand

Objective: Heat related illnesses are a common illness among conscripts during basic training course in Thailand and heat stroke is a major cause of death. Risk factors of heat related illnesses are generally known but there has not been a systematic review.

Materials and Methods: The authors conducted a systematic review using key words, including - ("heat injury" or "heat related illnesses" or "heat illness" or "heat related injury" or "heat stress") and ("military" or "conscripts" or "marine") and ("training" or "basic training course") and ("risk factor") and searched several electronic databases e.g. Pubmed and, -OVID during January 1990 and September 2018. Articles were selected according to a priori prospectively defined criteria. Analysis was done by descriptive statistics.

Results: Twenty-seven articles met the inclusion criteria. Just over half (55.5%) were original studies, including descriptive (25.9%) and case control studies (22.2%), and/or from the USA (52.9%), and/or involved the military (51.8%). The major identified risk factors in soldiers were: (i) abnormal body mass index (40.7%), (ii) inadequate hydration (40.7%), (iii) either not acclimatized or having low acclimatization (29.6%) and (iv) high ambient temperature (25.9%).

Conclusion: Knowledge of risk factors of heat related illnesses will help to prevent heat related illnesses among soldiers.

Keywords: Heat related illnesses, Heat related illness, Soldiers, Military, Risk factors

J Med Assoc Thai 2020;103(Suppl.4): 5-9
Website: http://www.jmatonline.com

Heat related illnesses are a major health challenge in military training with a reported incident rate of up to 30/100,000 population per year and an associated death rate 3.6/100 person per year. In developed countries such as in Japan, the heat related illnesses in the year 2010 was 53,843 cases(1) the United Kingdom, the heat related illnesses rate was 20/100,000 population per year(2). Which is close to Thailand. Most cases of heat related illnesses occur in the 2nd week of training, decreasing thereafter and stabilizing at about the 7th week of training.

Heat related illnesses can be divided into seven types, including heat edema, heat rash, heat syncope, heat cramp, heat tetany, heat exhaustion and heat stroke.

Studies of heat related illnesses in individual studies have identified as important risk factors but there has not, to the best of our knowledge, been a systematic review of heat related illnesses in military personnel soldiers, an important risk group. Therefore, we conducted such a review in military personnel and report our findings.

Correspondence to:

Deepreecha K.

Health Promotion and Preventive Medicine Division, Royal Thai Army Medical Department, Bangkok 10400, Thailand.

Phone: +66-86-6262305

E-mail: koccmed@gmail.com

Meterials and Matethods

In this review, the authors collected data from various sources, including textbooks, manuscripts, literature reviews, obtained from searches of Pubmed and OVID, using the keywords of ("heat injury" or "heat related illnesses" or "heat illness" or "heat related injury" or "heat stress") and ("military" or "conscripts" or "marine") and ("training" or "basic training course") and ("risk factor").

Inclusion criteria

Thai or English observational, case control or cohort studies reported risk factors of heat related illnesses in military or military-related occupations that were conducted during January 1990 and September 2018.

Exclusion criteria

The authors excluded experimental study or intervention studies.

Retrieved articles were examined for quality using the criteria of the Joanna Briggs Institute (2014).

Data analysis

Information of retrieved articles was classified according to type of study, year of publication, country of the author, and identified risk factors. The latter were divided into individual, environmental, and management risk factors, and combination of any of them. Data analyses were done by

How to cite this article: Deepreecha K, Buranatrevedh S. Factors associated with Heat related illnesses among soldiers: A Systematic review. J Med Assoc Thai 2020;103(Suppl.4): 5-9.

using frequency and percentage for general information of literatures and using frequency and percentage of type of risk factors.

Results

A total of 2,553 articles were identified but only 31 reported risk factors and, after review, 27 met our inclusion criteria (Figure 1).

Of the 27 identified articles, just over half were original papers and/or dealt with military populations; most were from the USA and were published in last decade (Table 1). About a quarter was descriptive studies and about half were case control studies.

The most important risk factors of heat related illnesses were abnormal body mass index (40.74%) and dehydration (40.74%). When classified according to the type of risk factor, individual risk factors were by far the most common (Table 2 to 5).

Discussion

Heat related illnesses are a major health challenge especially in military personnel who undergo rigorous training or strenuous work in hot environments. There are many types of risk factors that are associated with heat related illnesses and in the present study, the authors identified two key ones - high body mass index and dehydration. Other important risk factors that we identified were environmental temperature, relative humidity, location, altitude from sea level, delay diagnosis, and delay evacuation. In the present study, the authors found training to be familiar with heat dehydration and with the integrity of the body are important factors of heat related illnesses about which most studies did not mention heat accumulation as a major risk factor of heat related illnesses.

Most articles cite individual risk factors like diet, fluid intake whilst a minority of articles discusses several environmental risk factors, including ambient temperature, bed time temperature, relative humidity, location, and altitude above sea level. These factors are important to predict the occurrence of heat related illnesses. In addition, an

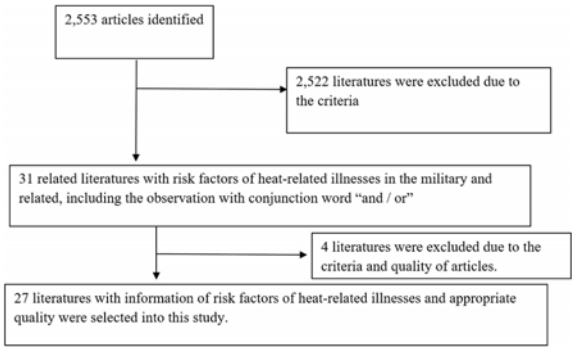

Figure 1. Showing the steps and results of literature selection.

Table 1. General data of literatures

General data	No. (%)
Type of literature	
Original article	15 (55.5)
Review article	9 (33.3)
Textbook	2 (7.4)
Others (expert opinion, concensus)	1 (3.7)
Publication year	
1991 to 2000	3 (11.1)
2001 to 2009	7 (25.9)
2010 to 2018	17 (63.0)
Study country	
USA	16 (52.9)
UK	2 (7.4)
Thailand	4 (14.8)
Qatar	1 (3.7)
Saudi Arabia	1 (3.7)
Singapore	1 (3.7)
Japan	1 (3.7)
Sri Lanka	1 (3.7)
Level of evidence/study design	
Experimental studies	1 (3.7)
Case control studies	6 (22.2)
Descriptive studies	7 (25.9)
Expert opinion	12 (44.4)
Meta analysis	1 (3.7)
Military research	
Military	14 (51.9)
Non-military	13 (48.1)
Total	27 (100)

Table 2. Risk factors of heat related illnesses

Risk factors	No. (%)
Abnormal BMI	11 (40.7)
Hydration	11 (40.7)
Unacclimatization/low acclimatization	8 (29.6)
Acute medical illness e.g.URI, diarrhea	7 (25.9)
Environmental temperature/ ambient temperature	7 (25.9)
Low fitness level	7 (25.9)
Delay treatment/management system	6 (22.2)
Chronic medical illness	6 (22.2)
Medication	6 (22.2)
Socioeconomic	6 (22.2)
Other environmental factor (air conditioning)	5 (18.5)
Age	5 (18.5)
Prolong exercise (strenuous training)	5 (18.5)
Humidity	5 (18.5)
History of EHI	4 (14.8)
Clothing	4 (14.8)
Human temperature	4 (14.8)
Location/sea level	4 (14.8)
Lack of rest/sleep deprivation	2 (7.4)
Body weight decrease	2 (7.4)
Timing	1 (3.7)
One day lag	1 (3.7)

Table 3. Types of reported risk factors

Individual risk factors	Environmental risk factors	Management risk factors
History of heat related illnesses	Level of hydration	Delay in seeking
Acclimatization	Clothing	treatment or
Fitness level	Humidity	management system
BMI	Ambient temperature	
Medical illness	Location/sea level	
Body weight	Timing	
Medication		
Human body temperature		
Sleep deprived		
Socioeconomic e.g. race, social income		
Gender		
Age		
Body temperature before day (bedtime temperature)		

Table 4. Individual Studied for types of risk factors of heat related illnesses among soldiers.

Author, Year of publication	Risk factors				
	Individual risk factors	Environmental risk factors	Management risk factors	Both individual and environmental risk factors	All risk factors
Nutong R, et al 2018 Thailand	✓				
Pumchand N, et al 2012 Thailand				✓	
Fuengfoo P, et al 2018 Thailand	✓				
Wijerathne B, et al 2016 Sri Langkla					✓
Bouchana A, et al 2007 Saudi Arabia				✓	
Jacklist B, et al 2016 USA					✓
Miyake Y, 2013 Japan					
Gardner JW, et al. 2004 USA		✓		✓	
Kark JA, et al 1996 USA			✓		
Kovat RS, et al 2008 UK					✓
Gronlund CJ, 2014 USA	✓				
Tustin AW, et al 2018 USA				✓	
Stacey MJ, et al 2015 UK				✓	
Wallace RF, et al 2006 USA	✓				
Pryor RR, et al 2015 USA				✓	
Korey Strigler Institute, University of Connecticus 2014. USA					✓
Chuang WC, et al 2015 USA				✓	
Gubernot DM, et al 2015 USA				✓	
Raciais S, et al 2015 Qatar				✓	
Semenza JC, et al 1996 USA					✓
Naiyapatana W, et al 2014 Thailand	✓				
Krueger Kalinskin MA, et al	✓				
Cleary M, 2007 USA			✓		
Smalley B, et al 2003 USA	✓				
Moore AC, et al 2015 UK				✓	
Gardner JW, et al 1996 USA	✓				
Erwin SD. 2015 USA	✓				

underappreciated factor is the body temperature one day before the heat related illnesses[4,11]. Another important risk category is management, which encompasses delays in diagnosis and evacuation[6,8,10,12,18,25].

Our review found that a number of articles did not mention or discuss factors like diet, bedtime temperature, the level of heat accumulation in the body, and the amount of drinking water consumed.

Table 5. Percentage of risk factors by type of risk factors

Type of risk factors	No. (%)
Individual risk factors[3,5,13,16,23,24,26,28,29]	9 (33.3)
Environmental risk factors[9,11]	2 (7.4)
Management risk factors[25]	1 (3.7)
Both individual and environmental risk factors[4,7,10,14,15,17,19-21,27]	10 (37.4)
All of risk factors[6,8,12,18,22]	5 (18.5)
Total	27 (100)

Knowing the risk factors for heat related illnesses can lead to strategies to reduce such risks. Rigorous training in the heat should not be undertaken by those with high body mass indices and for those who are in the heat; it is important to maintain hydration by carrying water bottles or having access to water or other fluids. Wearing a hat and loose clothing should provide greater comfort as a counter measure to environmental factors.

Key to the successful management of heat related illnesses is a greater awareness of its early symptoms and signs by soldiers/workers as well as front line health care professionals. Such awareness should result in more timely diagnosis and treatment and spare resources that might otherwise be used for emergency medical evacuation from the field. More research is needed on the level of knowledge that soldiers have of heat related illnesses through knowledge, attitude, and practice surveys. This will allow training programs to be better tailored to their needs and understanding. The present study not only shows personnel and environmental risk factors of heat related illnesses among soldiers, but also management risk factors and both personnel and environmental risk factors can lead to heat related illnesses among soldiers which in some cases are preventable: acclimatization, sleep deprivation, level of hydration, clothing, delay in seeking treatment or management system.

Another avenue of future research is the development of risk models to predict individual risks much in the same way that risk scores exist for respiratory and cardiovascular diseases. Such risk scores would need to be validated under field conditions, which would be challenging.

The main limitation of this review is that most studies have been conducted in Europe and the USA where terrain, weather, training conditions may be very different to those in Thailand and this limits the applicability of the findings. Nevertheless, this review has provided useful information and avenues for future research as well as data for updating guidelines.

Acknowledgements

Thank you to friends of the PhD. candidates and student program Community Medicine and Family Medicine and all of instructor from community department of faculty of medicine, Thammasat University that have provided useful suggestions for the development of this research. And thanks to the personnel of the health promotion and preventive medicine division, army medical department who have helped support this research successfully.

What is already known on this topic?

This topic is already known about regarding risk factors of heat related illnesses among soldiers and their useful to prevent heat related illnesses among soldiers and leading to factors in predictive modeling for heat related illnesses among soldiers.

What this study adds?

The present study shows that not only personnel risk factor and environmental risk factors of heat related illnesses among soldiers, but also management risk factors and both personnel and environmental risk factors can leading to heat related illnesses among soldiers too, and some risk factors are preventable: Acclimatization, Sleep deprived, Level of hydration, Clothing, Delay in seeking treatment or management system.

Potential conflicts of interest

The authors declare no conflicts of interest.

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ปัจจัยที่เกี่ยวเนื่องกับการเกิดการเจ็บป่วยจากความร้อนในทหาร: การทบทวนวรรณกรรมอย่างเป็นระบบ

คทาวุธ ดีปรีชา, สุรศักดิ์ บูรณตรีเวทย์

วัตถุประสงค์: การเจ็บป่วยที่เกี่ยวเนื่องกับความร้อนเป็นปัญหาที่พบได้บ่อยในการฝึกทหารใหม่ในประเทศไทย โดยเฉพาะอย่างยิ่งโรคลมร้อน ถือว่าเป็นสาเหตุหลักของการเสียชีวิตในการฝึกทหารใหม่ ปัจจัยเสี่ยงต่อการเจ็บป่วยที่เกี่ยวเนื่องกับความร้อนเป็นที่ทราบโดยทั่วไป แต่ยังไม่มีการศึกษาใดที่รวบรวมปัจจัยเสี่ยงเหล่านี้ เพื่อรวบรวมปัจจัยเสี่ยงที่เกี่ยวเนื่องกับการเจ็บป่วยที่เกี่ยวเนื่องกับความร้อนในทหาร

วัสดุและวิธีการ: การศึกษาในครั้งนี้ในการศึกษา เป็นรูปแบบการทบทวนวรรณกรรมอย่างเป็นระบบ (systematic review study) โดยใช้คำสำคัญในการสืบค้นข้อมูลได้แก่ (“heat injury” or “heat related illnesses” or “heat illness” or “heat related injury” or “heat stress”) and (“military” or “conscripts” or “marine”) and (“training” or “basic training course”) and (“risk factor”). โดยสืบค้นจากฐานข้อมูล Pubmed, OVID, PLoS One BMJ,เอกสารตำราอื่น ๆ ที่มีการตีพิมพ์ตั้งแต่ปี พ.ศ. 2533 ถึงกันยายน 2561 (ค.ศ.2018) โดยงานวิจัยที่ตรงหรือเหมาะสมกับการศึกษาจะถูกคัดเข้าในการศึกษาในครั้งนี้ วิเคราะห์ข้อมูลโดยใช้ความถี่ ร้อยละของเอกสารในการนำเสนอข้อมูลทั่วไปและปัจจัยเสี่ยงของการเจ็บป่วยที่เกี่ยวเนื่องกับความร้อน

ผลการศึกษา: จำนวนเอกสารที่ถูกคัดเข้าในการศึกษามีจำนวนทั้งสิ้น 27 ชิ้นงานที่มีความเหมาะสมและมีคุณภาพอยู่ในเกณฑ์สูง ส่วนใหญ่เป็นนิพนธ์ต้นฉบับ (ร้อยละ 55.55) ตีพิมพ์ตั้งแต่ พ.ศ. 2553 เดือนกันยายน พ.ศ. 2561 (ร้อยละ 62.97) มาจากประเทศสหรัฐอเมริกา (ร้อยละ 52.96) และเป็นงานวิจัยที่เกี่ยวข้องกับทหาร (ร้อยละ 25.93) ผลการศึกษาพบว่า ประกอบด้วย ปัจจัยส่วนบุคคล และปัจจัยด้านสิ่งแวดล้อม ได้แก่ การมีดัชนีมวลกายผิดปกติ (ร้อยละ 40.74) และการไม่คุ้นชินกับความร้อน (ร้อยละ 29.63) การได้รับน้ำไม่เพียงพอ (ร้อยละ 40.74) และอุณหภูมิสิ่งแวดล้อมที่สูง (ร้อยละ 25.93)

สรุป: การรับทราบถึงปัจจัยเสี่ยงจากการเจ็บป่วยจากความร้อน จะช่วยในการดำเนินการป้องกันการเจ็บป่วยจากความร้อนในทหารได้