Monitoring of the Bed Time Body Temperature and Body Weight to Prevent the Occurrence of Heat Stroke in the Royal Thai Army Recruits, Lopburi Province, Thailand

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Objective: *Heat stroke is still an important health problem in Thai army recruits. The authors aimed to evaluate a new method for preventing heat stroke in the newly army recruits during basic training in May-June 2006, by monitoring the bed time body temperature and body weight.*
Material and Method: *One thousand one hundred and fifteen recruits from five army units in Lopburi Province, Thailand were enrolled in the present study. Standardized questionnaire was used for data collection including unit information, personal information, environmental information and daily activity information. Bed time body temperature and body weight were recorded daily. Anyone who had a body temperature > 37.8°C or body weight lossing > 10% in 24 h had to stop training until these indicators were normal.*
Results: *There was no incidence of heat stroke in these army units during this training period. There were 191 recruits who had a body temperature > 37.8°C. The mean duration of the fever was 3.3 $\pm$ 3.3 days. The incidence of fever was 21.4 per 100 persons-month. There were 30 recruits with the body weight lossing > 10%. The duration of body weight loss was one day. Analyzed by Mixed Model using STATA program, there was statistically significant difference of the body temperature ($p < 0.001$) but not the body weight ($p = 0.644$) among the period of time.*
Conclusion: *This monitoring of the bed time body temperature and body weight seems to be effective for the prevention of the occurrence of heat stroke because there was no case of heat stroke in the present study. However, further large-scale study with a control group should be performed.*

Keywords: *Heat stroke, Army recruits, Body temperature, Body weight, Prevention*

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Heat stroke is defined as a core body temperature in excess of 40.5°C (105°F) with associated central nervous system dysfunction in the setting of a large environmental heat load that cannot be dissipated[1-3]. Frequently encountered complications include acute respiratory distress syndrome (ARDS), disseminated intravascular coagulation, renal or hepatic failure, hypoglycemia, rhabdomyolysis and seizures[3,4].

Heat stroke is classified into 2 types *i.e.* classic (nonexertional) heat stroke and strenuous (exertional) heat stroke. Classical heat stroke affects individuals with underlying chronic medical conditions that either impair thermoregulation or prevent removal from a hot environment. These conditions include cardiovascular

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diseases, neurologic or psychiatric disorders, obesity, anhidrosis, extremes of age, and use of drugs such as anticholinergic agents or diuretics[5-7]. The latter, exertional heat stroke, generally occurs in the young, otherwise healthy individuals who engage in heavy exercise during periods of high ambient temperature and humidity. Typical patients are athletes and military recruits in basic training[5,8]. Patients with heat stroke have an acute mortality rate of 21 percent[9].

A number of young Thai men have been recruited to the Royal Thai Army twice a year *i.e.* in May and November. Basic training for these recruits is about twelve weeks in each period. The recruits had to obtain the strenuous training in physical activities and knowledge about the army. Physical adaptation to the heat is different in each individual which can be divided into two categories *i.e.* acclimatization and non-acclimatization. For those who are trained in May, the end of summer and the beginning of the rainy season in Thailand, heat stroke is caused because of high temperature and humidity. The incidence of heat stroke in the recruits in Lopburi Province, Thailand during 2003 to 2006 were 12 cases (unpublished data). Seven cases had acute renal failure and one case developed chronic complications, chronic kidney disease which had to be on hemodialysis weekly. Even with meticulous monitoring, the incidence of heat stroke still occurs every year. Fever and dehydration are one of the important risk factors of heat stroke. Primary care unit (PCU) of Anandamahidol Hospital detected 97 and 146 recruits who presented with fever during the training in May-June 2004 and 2005, respectively (unpublished data). Proper management of these 2 risk factors *i.e.* fever and dehydration might reduce the incidence of heat stroke. The present study applied the new method by monitoring of the bed time body temperature and body weight which provide the detection of fever and dehydration, respectively. The authors aimed to evaluate whether this intervention could prevent heat stroke in the recruits during the training period in Lopburi Province, Thailand.

Material and Method

Study population

The present study was conducted during May-June, 2006. One thousand one hundred and fifteen recruits participated in the present study. They were recruited in five army units in Lopburi province, Thailand. All subjects were male aged between 19-21 years with a mean age of 20.9 ($\pm$ 1.2) years. Informed consent was obtained from all subjects.

Data collection

Standardized questionnaire was used for data collection which was divided into 4 sections: unit information, personal information, environmental information and daily activity information. Data of each unit including name, number of the recruits and sea level were collected. Personal information of all subjects such as weight and height for calculating body mass index (BMI) and the past history of acclimatization were recorded. Environmental information consisted of ambient temperature, relative humidity and heat index and daily activity information consisted of training areas, clothes, water intake, urine color, bed time body temperature and body weight were recorded daily.

The heat index was translated from a wet and dry bulb thermometer into flag color to indicate the level of training and water consumption for each period of day at 7:00 am, 10:00 am, 1:00 pm and 4:00 pm. Each recruit had the body temperature and body weight recorded daily before bed time. Anyone who had a body temperature > 37.8°C or body weight loss > 10% in 24 h had to rest the next day or until these indicators returned to normal.

Statistical analysis

All information was recorded and analyzed using SPSS, Chicago IL USA Software package. Analysis of variant (ANOVA) was used to detect the significant difference of means among groups. The difference of the body temperature and the body weight among the time were analyzed by Mixed Model, STATA/SE for version 9.2 (StataCorp LP, College Station, TX). A p-value of < 0.05 was considered statistically significant.

Results

Among five army units, the 1st Battalion of the 31st Infantry Regiment, the King's Guard, the 2nd Battalion of the 31st Infantry Regiment, the King's Guard, the 31st Infantry Regiment, the King's Guard, the Army Aviation Center and the Artillery Center had 183, 179, 182, 198 and 373 recruits, respectively. The sea level of the first three army units was 116 meters while the Army Aviation Center and the Artillery Center was 95 meters. Most of the recruits came from Northern and Northeastern Thailand.

Approximately half of the recruits were non-acclimatization. The non-acclimatization in the 1st Battalion of the 31st Infantry Regiment, the King's Guard, the 2nd Battalion of the 31st Infantry Regiment, the King's Guard, the 31st Infantry Regiment, the King's

Guard, the Army Aviation Center and the Artillery Center were 45.7%, 59.7%, 29.1%, 44.9% and 60.6% respectively.

Overall average BMI was 21.4 ± 3.1 kg/m^2. There were no significant differences of BMI among these 5 units. There was a significant difference of the ambient temperature and the relative humidity using One-way ANOVA among units ($p < 0.001$). Analyzed by HDS and LSD, the ambient temperature of the Artillery Center was highest (34.0°C, $p < 0.001$) and no statistical significant difference in the others. The relative humidity of the 1st Battalion of the 31st Infantry Regiment, the King's Guard was lowest (57.4%, $p < 0.001$). The highest relative humidity was in the 2nd Battalion of the 31st Infantry Regiment, the King's Guard (67.7%, $p = 0.024$).

The ambient temperature and the relative humidity among the times of day were significantly different using One-way ANOVA ($p < 0.001$). The ambient temperature at 7:00 am was lowest (30.5°C, $p = 0.004$). Post Hoc Analyzed by HDS and LSD, the ambient temperature was highest at 1:00 pm and 4:00 pm (33.7°C and 33.3°C, $p < 0.001$). The relative humidity was highest at 07:00 am (67.9%, $p < 0.001$) and lowest at 1:00 pm and 4:00 pm (60.6% and 60.7%, $p < 0.001$).

The level of heat index was shown by the different flag color *i.e.* white, green, yellow, red and black which were 34.1%, 28.1%, 18.1%, 10.3% and 9.4% respectively. The black flag was applied mostly at 7:00 am. In contrast, the white flag was applied mostly in other periods of each day. Accuracy of the determination of the flag color by calculating the records of dry bulb thermometer and the relative humidity in each period was 95.4%. There were 36 missing of the color of flags. Twenty three and thirteen incidences of under and over-determination were detected. The training areas were mostly outdoor (36.1%).

One third of the recruits drank 3 glasses of water per one training period. Most of the recruits had dark yellow urine and 55.5% voided one time per one training period. During ten weeks of the basic training, there was no incidence of heat stroke in these army

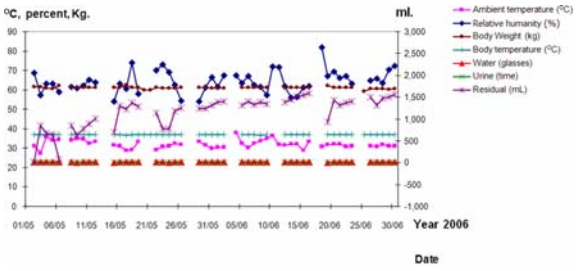

Fig. 1 The daily recorded ambient temperature and relative humidity in the army units and the daily recorded bed time body weight, bed time body temperature and darkness of urine of the recruits

Table 2. The average of temperature and relative humidity at 4 different periods of the day

Periods of Day	Temperature	Relative Humidity
07:00 a.m.	30.5 ± 3.9	67.9 ± 11.4
10:00 a.m.	32.4 ± 2.3	64.1 ± 8.7
01:00 p.m.	33.7 ± 2.4	60.6 ± 9.1
04:00 p.m.	33.3 ± 4.0	60.7 ± 10.3
Total	32.5 ± 3.5	63.4 ± 10.3
p-value	< 0.001	< 0.001

Table 1. Characteristics of each army unit and the recruits

Variables (means ± SD)	Units					Total	p-value
	R31*	R311**	R312***	AAC****	AC*****		
The sea level (meters)	116	116	116	95	95		
The number of recruits	182	183	179	198	373	1,115	
The acclimatized recruits (%)	70.9	54.3	40.3	55.1	39.4	50.0	
Age (years)	20.9 ± 1.0	20.9 ± 1.2	20.8 ± 1.5	21.0 ± 1.2	20.9 ± 1.2	20.9 ± 1.2	0.448
Body Mass Index (BMI) (kg/m^2)	21.3 ± 2.8	21.8 ± 3.8	20.9 ± 2.5	21.4 ± 3.0	21.4 ± 3.3	21.4 ± 3.1	0.077

*R31: the 31st Infantry Regiment, the King's Guard
**R311: the 1st Battalion of the 31st Infantry Regiment, the King's Guard
***R312: the 2nd Battalion of the 31st Infantry Regiment, the King's Guard
****AAC: the Army Aviation Center
*****AC: the Artillery Center

units. There were 191 recruits who had a body temperature > 37.8°C. The mean duration of the fever was 3.3 $\pm$ 3.3 days. The incidence of fever was 21.4 per 100 persons-month. There were 30 recruits with the body weight loss > 10%. The duration of body weight loss was one day. None of these recruits had both body temperature > 37.8°C and body weight loss > 10% at the same time (no data presented). Analyzed by Mixed Model using STATA program, there was statistically significant difference of the body temperature ($p < 0.001$) but not the body weight ($p = 0.644$) among the period of time.

Discussion

Heat stroke, the preventable disease, is one of the common diseases which occur in the basic training in the Royal Thai Army. Chronic complications such as end stage renal disease (chronic kidney disease) are a burden. In the past, the Royal Thai Army Medical Department had the policy to prevent the occurrence of heat stroke by measuring of the relative humidity and the ambient temperature using wet and dry bulb thermometer. However, a few cases of heat stroke were reported in this population every year.

The present study introduces the new monitoring to effectively prevent an occurrence of heat stroke by measurement of the bed time temperature and body weight. In 2003-2006, 12 cases of heat stroke occurred annually but there was no incidence of heat stroke in the present study. High fever, body temperature > 38.5°C, is the important risk factor and dehydration status can precipitate the occurrence of heat stroke. So the measurement of losing weight is a feasible assessment of the hydration status. The suggestion is that the decrease more than 10% from previous body weight represents a poor hydration status. The present study was limited in the methodology. There was no control group in the present study because the measuring of the bed time body temperature and body weight were the useful and feasible intervention that should be applied to all subjects. The exception of the monitoring may be too harmful because of the fatal disease, heat stroke for the recruits. The control group by not applying the intervention, monitoring of the body temperature and body weight, for comparing of the incidence of the heat stroke may lead to get rid of the defect of the methodology but the risk and the benefits should be considered.

From the descriptive data showed half of the recruits were non-acclimatization. The trainers should be suggested to gradually step the training program up for prevention of heat stroke and the acclimatization daily work schedule should be applied to the basic training. The weather in the morning was colder than the others but the humidity was the highest. The physical fitness test usually applied to the recruits in the morning. The strenuous activities should aggravate the incidence of heat stroke. The staff of the testing stations of the physical fitness test should be warned about the high probability of heat stroke in the daily morning because of the high ambient humidity. The authors can detect the missing of the flag's color 4.6% and it can lead to the occurrence of the heat stroke. The method of the applied color flags should be strict. The present study was performed in some basic training units of the Royal Thai Army. The further study needs to apply to other training units in the other parts of Thailand. The variation of seasons directly effects the ambient temperature and the relative humidity. So the surveillance of heat stroke in the basic training should be developed in every period as a whole year.

This monitoring of the bed time body temperature and body weight seems to be effective for the prevention of the occurrence of heat stroke because there was no case of heat stroke in the present study in the contrast that there were cases of heat stroke in the previous years and the other training units which this monitoring was not applied in the same period of the present study. For the medical aspect, this monitoring by measurement of the bed time body temperature and body weight were the method to early detect the risk factors of heat stroke, fever and dehydration status. This monitoring was also valuable in the behavioral aspect that it was the symbolic mental mark for reminding both recruits and commanders for the occurrence of heat stroke. The concurrent policy of the Royal Thai Army in heat stroke prevention is implemented in each unit which might influence the practice of training activity resulting in the success of the program.

Potential conflicts of interest

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การติดตามอุณหภูมิกายและน้ำหนักก่อนนอนเพื่อป้องกันการเกิดโรคลมร้อนในทหารกองประจำการจังหวัดลพบุรี ประเทศไทย

นรวีร์ พุ่มจันทน์, วนิดา เทศนา, สุภัค แซ่โง้ว, ราม รังสินธุ์, พจน์ เอมพันธุ์, มฑิรุทธ มุ่งถิ่น, นรีรัตน ศรีเลณวัติ

วัตถุประสงค์*: โรคลมร้อนเป็นปัญหาสุขภาพที่สำคัญของทหารกองประจำการ คณะผู้นิพนธ์ได้ศึกษาวิธีการป้องกันโรคลมร้อนวิธีใหม่ในทหารกองประจำการใหม่ระหว่างการฝึกในช่วงเดือนพฤษภาคมถึงเดือนมิถุนายน พ.ศ. 2549 โดยการใช้การวัดอุณหภูมิกายและน้ำหนักตัวก่อนนอน*

วัสดุและวิธีการ*: กำลังพลทหารกองประจำการจำนวนทั้งสิ้น 1,115 นาย จากหน่วยทหารจังหวัดลพบุรีจำนวน 5 หน่วย ได้เข้าร่วมโครงการ ซึ่งได้ทำการบันทึกข้อมูลทั่วไปของหน่วย ข้อมูลส่วนบุคคล สภาวะสิ่งแวดล้อมและกิจกรรมการฝึกทหารในแต่ละวัน และมีการวัดอุณหภูมิและน้ำหนักตัวก่อนนอนทุกวัน เมื่อพบว่าทหารมีอุณหภูมิกายเกิน 37.8°C หรือน้ำหนักลดลงร้อยละ 10 ภายใน 24 ชั่วโมง จะให้ทหารหยุดฝึกจนกว่าค่าเหล่านี้จะปกติ*

ผลการศึกษา*: ไม่พบการเกิดโรคลมร้อนในช่วงการศึกษา พบทหารกองประจำการที่มีอุณหภูมิกายมากกว่า 37.8°C จำนวน 109 นาย คิดเป็นอุบัติการณ์เท่ากับ 21.35/100 คน/เดือน โดยมีค่าเฉลี่ยของระยะเวลาการมีไข้เท่ากับ 3.3 (± 3.3) วัน พบทหารกองประจำการที่มีน้ำหนักตัวลดลงมากกว่าร้อยละ 10 จำนวน 30 นาย ระยะเวลาที่มีน้ำหนักลดนาน 1 วัน เมื่อวิเคราะห์ด้วย Mixed Model โดย STATA program พบว่าอุณหภูมิกายก่อนนอนมีการเปลี่ยนแปลงตามระยะเวลาของการฝึกอย่างมีนัยสำคัญทางสถิติ ($p < 0.0001$) แต่ไม่พบการเปลี่ยนแปลงของน้ำหนักตัวตามระยะเวลาของการฝึก ($p = 0.644$)*

สรุป*: การเฝ้าระวังอุณภูมิกายและน้ำหนักตัวก่อนนอนดังกล่าวอาจมีประสิทธิภาพในการป้องกันการเกิดโรคลมร้อนได้ดีเนื่องจากไม่พบผู้ป่วยโรคลมร้อนในการศึกษาครั้งนี้ อย่างไรก็ตามควรมีการศึกษาที่มีกลุ่มควบคุมเพิ่มเติมในอนาคต*