Heat impact on schoolchildren in Cameroon, Africa: potential health threat from climate change

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Heat impact on schoolchildren in Cameroon, Africa: potential health threat from climate change

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Background: Health impacts related to climate change are potentially an increasing problem in Cameroon, especially during hot seasons when there are no means for protective and adaptive actions.
Objective: To describe environmental conditions in schools and to evaluate the impact of heat on schoolchildren's health during school days in the Cameroon cities of Yaoundé and Douala.
Methods: Schoolchildren ($N=285$) aged 12–16 years from public secondary schools completed a questionnaire about their background, general symptoms, and hot feelings in a cross-sectional study. In Yaoundé, 50 schoolchildren were individually interviewed during school days about hourly symptoms (fatigue, headache, and feeling very hot) and performance. Lascar dataloggers were used to measure indoor classroom temperatures and humidity.
Results: There was a significant correlation between daily indoor temperature and the percentages of schoolchildren who felt very hot, had fatigue, and headaches in Yaoundé. A high proportion of schoolchildren felt very hot (48%), had fatigue (76%), and headaches (38%) in Yaoundé. Prevalences (%) were higher among girls than boys for headaches (58 vs 39), feeling 'very hot overall' (37 vs 21), and 'very hot in head' (21 vs 18). Up to 62% were absentminded and 45% had slow writing speed. High indoor temperatures of 32.5°C in Yaoundé and 36.6°C in Douala were observed in school.
Conclusions: Headache, fatigue, and feeling very hot associated with high indoor air temperature were observed among schoolchildren in the present study. Longitudinal data in schools are needed to confirm these results. School environmental conditions should be improved in order to enhance learning.

Keywords: *heat*; *fatigue*; *headache*; *very hot*; *indoor temperature*; *Cameroon*; *schoolchildren*

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Health impacts related to climate change have been given increasing attention during recent years. Negative impacts of heat exposure on human health and performance have been known for several decades (1–5). In low income countries and in Cameroon, there are increasing problems of heat-related ill-health, especially during hot seasons when there are no means for protective and adaptive actions such as air conditioning and water supply (5–7). Heat exposure can affect physical and mental capacity and lead to heat exhaustion or heat stroke in extreme cases (8). The main factor underlying these effects is an increase in core body temperature (hyperthermia) (2, 8). When body temperatures exceed 39°C, acute heat disorders (e.g. heat stroke) may occur. Above 40.6°C, life-threatening severe hyperpyrexia starts to occur and can lead to death (2, 8–10).

The human body functions and performs optimally at a core body temperature of around 37°C (5). For the body to maintain this temperature and sustain heat balance, it uses thermoregulatory system processing signals from the hypothalamus in the central nervous system and then regulates the cardiovascular system, kidneys, and water content in the intravascular system, interstitial places, and cells by hormones and behavioral response actions (e.g. removing clothing). However, the need for thermoregulation is highly affected by six factors (1). These are: ambient air temperature, radiant temperature, air humidity, air movement (wind speed), clothing,

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and metabolic heat generated by physical activity. The most important physiological regulatory mechanism for thermoregulation is sweating. With massive sweating, there is dehydration and loss of fluids and salts. Dehydration affects physical and mental performance at losses of as little as 1% (1, 11). Studies performed in climate chambers and actual classrooms found reading speed, reading comprehension, and multiplication performance of schoolchildren to be poorer with temperatures of 27–30°C (12). An increase in air temperature has a negative effect on health and work performance (11, 13–15). Increased temperatures and low outdoor air supply rates can also cause 'sick building syndrome' symptoms such as headaches, difficulty in concentrating, fatigue, and lethargy (11, 16, 17). In a previous study on Cameroon schoolchildren, we found that headache, fatigue, dizziness, and malaria were the most prevalent health problems (18). As climate change brings increases in temperature, these problems may increase. Mental performance and attendance at school may also be affected by heat in schools.

To our knowledge, there is no study on daily heat exposure and the impact of heat on Cameroon schoolchildren. The aim of the present study is to describe environmental conditions in schools and evaluate the impact of heat on schoolchildren's health during school days in Yaoundé and Douala.

Methodology

Settings

Data were collected in Yaoundé and Douala. Yaoundé is the capital city of Cameroon and has more than two million inhabitants and a land area of 297 km^2. Douala is located in the coastal zone of the central province, the economic center of Cameroon, and is one of the hottest cities. Douala has more than three million inhabitants (and is the most densely populated area in Cameroon), and contains most of the urbanized and industrial areas of the country. The main diseases in Douala and Yaoundé are malaria, respiratory diseases, diarrheal diseases, HIV/AIDS, tuberculosis, hypertension, obesity, and cardiovascular diseases. Houses are made of cement blocks, bricks, or shaped stones with a roof of cement, zinc, or tile (19). Household furnishings and belongings are characterized by cooking with gas (45%) or an open fire using wood, ownership of televisions, radios (81%), mobile phones (10%), and cars (19). About 22% of the population uses a water closet, electricity coverage is 97%, and a water supply in the home is 90%. The school attendance rate is 94% in Yaoundé and Douala (20).

Weather and climate in the study regions

Cameroon is experiencing climate change characterized by increased temperatures during dry seasons and early rains (with droughts and flooding). This problem is exacerbated in the north and southwest provinces and cities of Yaoundé and Douala as compared to other provinces and cities. The temperature trends on Fig. 1, assembled by Kjellstrom and Lemke for this project from the US NOAA global climate website (http://www.noaa.gov/), show that both average temperature and average dew point (absolute humidity) increased consistently during the last 30 years at the two main Cameroon city airports. The linear equations show increase per year. Thus, 0.0284°C per year is equivalent to 2.8°C per century. In Yaoundé, data are missing for certain years and the trends are more varied. However, except for the maximum temperature temperatures continue to increase (Fig. 1). These data show annual trends and to get a better understanding of the actual heat stress during the hottest periods, monthly and daily data would be required. In Douala, the increasing dew point combined with the increasing temperature means a significant increase in heat stress.

School and classroom description

The school day is from 7:30 am to 15:30 pm with two breaks; a morning break is from 10:15 to 10:30 am and a lunch break is from 12:30 pm to 13:30 pm. On Wednesdays, schools close at 12:30 pm. Classrooms have no water supply, electricity, air conditioning, or fans. Each classroom has windows. Sometimes, windows are unconventionally made by creating box-like openings in one wall section. The floors and walls are made of cement blocks and the roof is made of cement or tile. The desks are made of planks and placed in rows of six columns. Students sit three to a desk. The boys wear a uniform of trousers and shirts and girls wear dresses. The uniforms are made of cotton. Boys have short haircuts and girls have braided hair. The schoolyard has tap water.

Study population

Boys and girls, aged 12–16 years, were recruited from three public secondary schools randomly selected in Yaoundé and Douala. Two schools were randomly selected from Yaoundé (school 1, school 2) and one was randomly selected from Douala (school 3). Two second grade classrooms were randomly selected from the two schools in Yaoundé. Two second grade classrooms were randomly selected from the school in Douala. All students from each classroom who were present at the time of data collection were included. In total, 285 schoolchildren completed the study. Permission to carry out the study was obtained from the school headmasters and each of the schoolchildren prior to study conduct. Ethical permission was obtained from the medical faculty of the University of Yaoundé, Cameroon.

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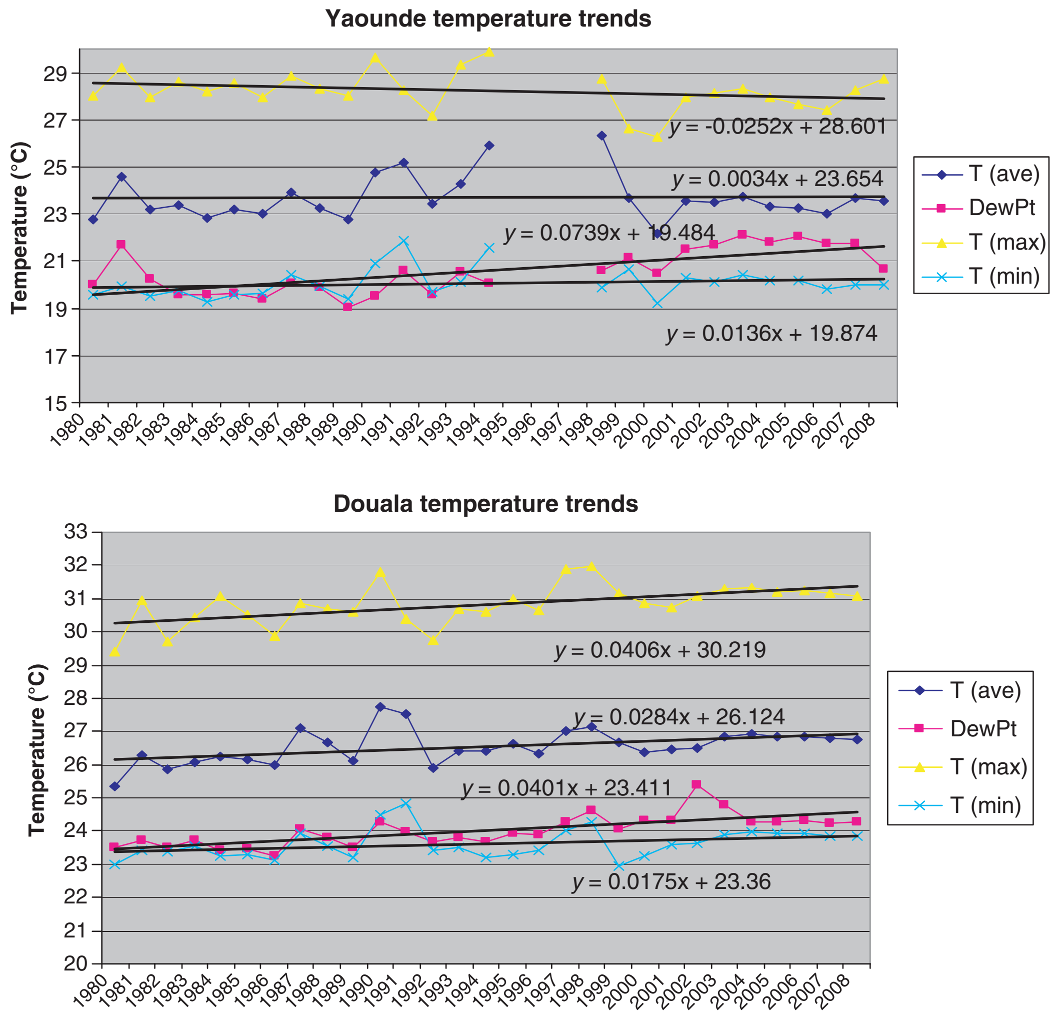

Fig. 1. Temperature trends in the Cameroon cities of Yaoundé and Douala. T(ave) is mean annual temperature, DewPt is mean annual dew point (an index of absolute humidity), Tmax and Tmin are annual averages of maximum and minimum temperature. The lines are fitted linear regressions with $x =$years: 1980–2008 and $y =$the level of each variable in degrees Celsius.

Data collection

Cross-sectional data were collected. The questionnaire was written in French by study personnel. Study personnel consisted of one public health expert, two nurses, and four university students. Most of the study personnel were trained during a previous study about schoolchildren's nutrition. The others were trained a week before the present study. Interviews were performed only during breaks, lunch, or after school. We could not interview all of the schoolchildren each day due to time constraints and absence of those who went out for lunch, breaks, to drink water, or left for home before the interviews were conducted. Moreover, the study team was not large enough to interview all schoolchildren each day/hour. However, interview speed and skills improved during data collection. Each interview lasted for about 45 min.

All schoolchildren ($n = 285$) in Yaoundé ($n = 174$) and Douala ($n = 111$) completed the questionnaire about their background (age, sex), general symptoms, and hot feeling. The background questionnaire was done at the beginning of the week and the general questionnaire/hot feeling was done at the end of the week. In Yaoundé (school 1, March 15–19, 2010; school 2, March 22–26, 2010), 50 of 174 students were individually interviewed about hourly symptoms and performance. Some schoolchildren were excluded because of missing data. A Lascar datalogger was used to measure indoor temperature, dew point, and humidity in the school 1 classroom (from 7:38 am to 15:38 pm) March 15–19, 2010 and from March 22–26, 2010 in the classroom for school 2 (from 7:34 am to 14:34 pm) in Yaoundé. The datalogger was fixed in one roof corner of the classroom. In school 3, a Celsius thermometer was used to measure the daily indoor temperature and relative humidity in classrooms from March 22–26, 2010 in Douala (school 3). In addition, outdoor temperatures were measured using a Celsius thermometer in Douala and Yaoundé. The thermometer was placed across the shadow of a window with an outside cable (in the shadow) to measure outdoor temperatures. The body weight of each student in light clothing and no shoes was measured to the nearest 0.1 kg using an electronic scale (Seca model 826, Bradford, UK) in the morning in Yaoundé. An 8 hour (from 7:30 am to 15:30 pm) symptoms and school performance interview was recorded for Monday, Tuesday, Wednesday, and Thursday in Yaoundé (school 1 and school 2). The interview recall for Friday should have been done on Saturday but as there is no school on Saturday we had to omit these. The students were asked to recall all symptoms that they felt and school performance undertaken during the previous day from 7:30 am to 15:30 pm. This interview recall was about symptoms (i.e. fatigue, headache), hot feeling (i.e. hot, very hot), and school performance (i.e. writing speed, level of understanding, absentmindedness) from 7:30 am to 15:30 pm during the previous day. We have previously used the same method for 24-h dietary recall to collect information about food consumption (21). Individual interviews lasted about 45 min and were conducted at the school. Body temperature (°C) of the schoolchildren was also measured in Yaoundé.

Data analysis

Data were analyzed using SPSS version 15 and Microsoft Excel 2007. Descriptive statistics by school and week (Yaoundé and Douala) were done for fatigue, hot/very hot, fever, vertigo, headache, nausea, thirst, malaria, and fever. Scatter plots, linear regression, and correlation (with Pearson correlation coefficient) were used to investigate the relationship between indoor air temperature and the percentage of schoolchildren who felt very hot, had fatigue, and had headaches in Yaoundé. Daily (Monday to Friday) and hourly (7:30 am to 15:30 pm) indoor air temperature, humidity, and dew point in Yaoundé (week 1 and week 2) were computed. The percentage of schoolchildren performance in Yaoundé was computed and included writing speed, lack of understanding, and absentmindedness. Outdoor air temperature in Yaoundé and Douala as well as indoor air temperature and humidity in Douala was described.

Results

The mean ages were 12.7 ± 1.4 years in school 1, 13.3 ± 1.2 years in school 2, and 12.9 ± 1.3 years in school 3. Girls were heavier than boys, with mean weights (kg) of 49.9 ± 9.2 vs 45.1 ± 8.3 in school 1, and 46.8 ± 9.3 vs 44.7 ± 7.6 in school 2. Overall, the mean body temperature was 37.6°C; 30 children had a body temperature of at least 38°C in Yaoundé. Table 1 describes the characteristics of the schoolchildren during the 2-week study period in Yaoundé and Douala. School 1, school 2, and school 3 are three different groups of schoolchildren. Up to 75% of the children reported fatigue, more than 60% were thirsty, and 49% had a headache. More than a third slept in class, 31% felt very hot overall, and 20% felt very hot in the head. Prevalences (%) were higher among girls vs boys for sickness (17 vs 12), thirst (63 vs 60), fatigue (77 vs 71), vertigo (20 vs 15), malaria (9 vs 6), headache (58 vs 39), very hot overall (37 vs 21), very hot in head (21 vs 18), and sleeping in class (40 vs 32) – although

Table 1. Characteristics (percentage in%, with number in brackets) of schoolchildren

	Total	Girls/boys[a]	School 1[b]	School 2[c]	School 3[d]
N	285	163/122	89	85	111
Slept in class	36 (99)	40/32	39 (35)	43 (32)	29 (32)
Sick	15 (40)	17/12	10 (9)	21 (15)	14 (16)
Thirsty	62 (166)	63/60	47 (42)	64 (45)	71 (79)
Fatigue	75 (202)	77/71	73 (65)	80 (58)	73 (79)
Vertigo	18 (48)	20/15	14 (12)	23 (17)	18 (19)
Malaria	8 (21)	9/6	5 (4)	13 (9)	7 (8)
Fever	5 (14)	6/5	2 (2)	12 (8)	4 (4)
Headache*	49 (134)	58/39	55 (49)	60 (44)	38 (41)
Nausea	13 (35)	13/12	7 (6)	22 (16)	12 (13)
Very hot overall*	31 (78)	37/21	20 (17)	19 (14)	49 (47)
Very hot in the head*	20 (50)	21/18	22 (19)	14 (10)	21 (21)

[a]Percentage (%) of girls vs boys.
[b]School 1, week 1: March 15–19, 2010 in Yaoundé.
[c]School 2, week 2: March 22–26, 2010 in Yaoundé.
[d]School 3, week 2: March 22–26, 2010 in Douala.
*Significant differences between boys and girls ($P = 0.010$; 0.014; 0.027, for headache, very hot overall, and very hot in the head, respectively).
Note. School 1, school 2, and school 3 are three different groups of schoolchildren.

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significant only for headache ($P = 0.010$), very hot overall ($P = 0.014$), and very hot in head ($P = 0.027$). Prevalences of all symptoms except for very hot overall and very hot in head were higher during week 2, school 2 (March 22–25) than week 1, school 1 (March 15–18) in Yaoundé (Table 1).

Figs. 2–4 show that there was a significant and positive correlation between indoor air temperature and the percentages of schoolchildren, who felt very hot, had fatigue, and had headaches in schools 1 and 2 in Yaoundé. School 1 and school 2 are two different groups of schoolchildren. The correlation coefficient was strong for very hot ($P < 0.001$), fatigue ($P = 0.002$), and headache ($P = 0.001$) in school 1, week 1 and strong for very hot ($P < 0.001$), weak for fatigue ($P = 0.037$), and headache ($P = 0.267$) in school 2, week 2. During the day, percentages of very hot, fatigue, and headaches increase linearly with indoor air temperature in Yaoundé (Figs. 2–4). Comparing the slopes of Figs. 2–4 between schools indicate heterogeneity in the association of temperature and symptoms.

The within day comparisons (between 12:30 am and 15:30 pm) indicated that feeling very hot and a headache

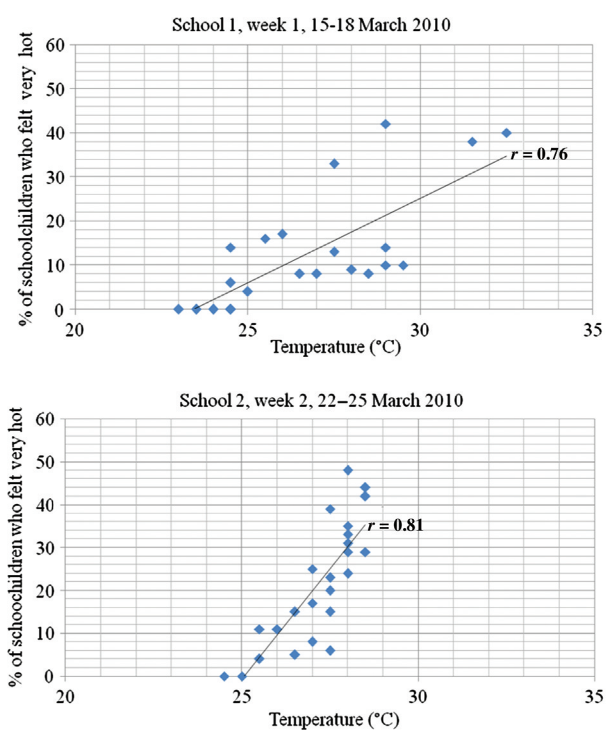

Fig. 2. Scatter plot showing the relationships between the temperature and the percentage of schoolchildren who felt very hot in Yaoundé. The lines are fitted linear regressions with x = temperature in degrees Celsius and y = percentage (%) of schoolchildren who felt hot from Monday to Thursday between 7:30 and 15:30, r is the Pearson correlation coefficient between temperature and very hot ($P < 0.001$, school 1 and school 2). School 1 and school 2 are two different groups of schoolchildren.

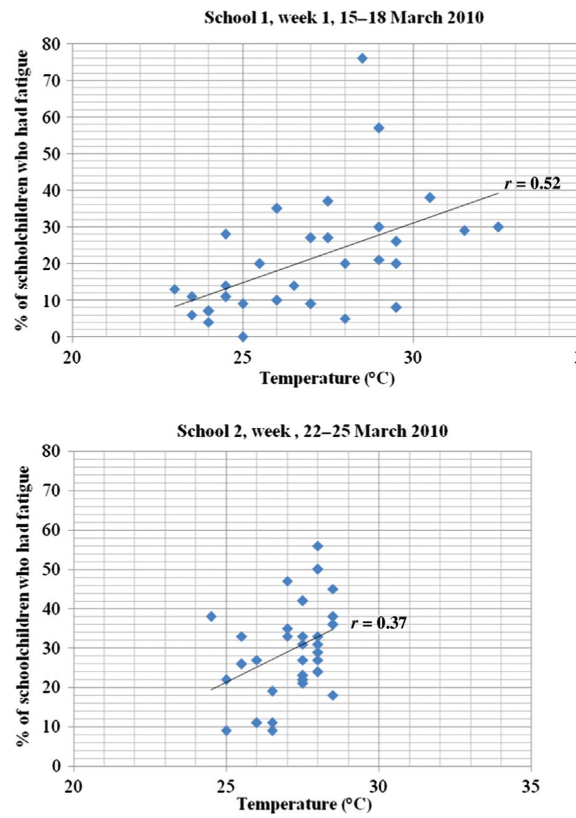

Fig. 3. Scatter plot showing the relationships between the temperature and the percentage of schoolchildren who had fatigue in Yaoundé. The lines are fitted linear regressions with x = temperature in degrees Celsius and y = percentage (%) of schoolchildren who had fatigue from Monday to Thursday between 7:30 and 15:30, r is the Pearson correlation coefficient between temperature and fatigue ($P = 0.002$, school 1 and $P = 0.037$, school 2). School 1 and school 2 are two different groups of schoolchildren.

was associated with indoor temperature and more prevalent on the hottest days especially during week 1, school 1 ($r = 0.72$ and 0.53, very hot and a headache, respectively, school 1).

The highest proportion of students who felt very hot (48%) was observed on March 24 in Yaoundé. The highest proportions of fatigue (76%) and headache (38%) were observed on March 18 and 23, respectively, in Yaoundé.

The proportion of schoolchildren with poor performance increases during the day. Up to 62% were absent-minded, 45% had slow writing speed, and 25% did not understand the lessons in Yaoundé.

The indoor air temperatures, humidity, and dew points in Yaoundé are presented in Fig. 5. The indoor air temperatures, humidity, and dew points are presented from Monday to Friday for week 1, school 1 (from 7:38 am to 15:38 pm) and week 2, school 2 (from 7:34 am to 15:34 pm) in Yaoundé. Daily indoor air temperature

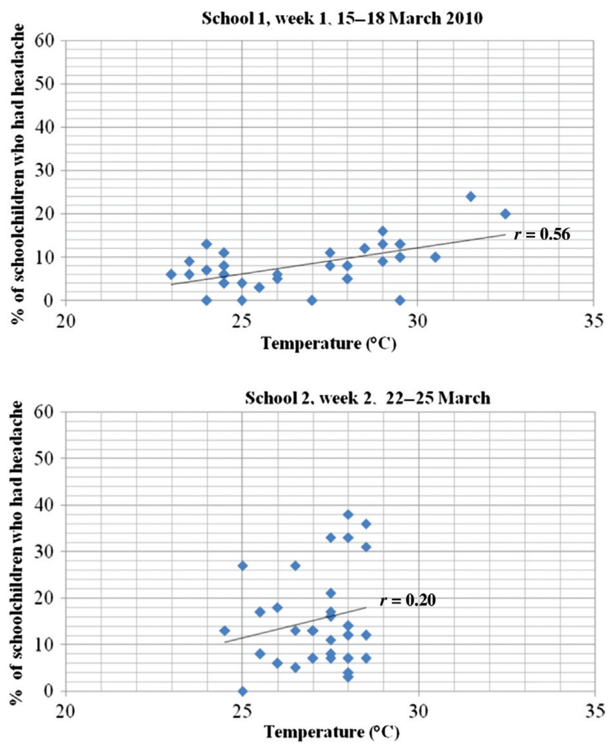

Fig. 4. Scatter plot showing the relationships between the temperature and the percentage of schoolchildren who had headaches in Yaoundé. The lines are fitted linear regressions with x = temperature in degrees Celsius and y = percentage (%) of schoolchildren who had headaches from Monday to Thursday between 7:30 and 15:30 and r is the Pearson correlation coefficient between temperature and headache (P = 0.001, school 1 and P = 0.267, school 2). School 1 and school 2 are two different groups of schoolchildren.

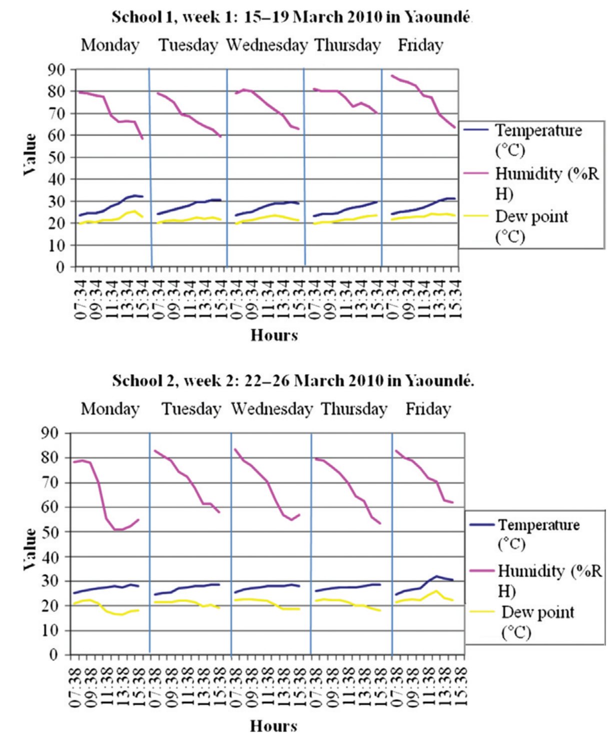

Fig. 5. Datalogger of indoor air temperature, humidity, and dew point by hours from Monday to Friday from 7:30 to 15:30 in classrooms in Yaoundé. Temperature, dew point (an index of absolute humidity), and humidity (percentage relative humidity) are given by hours from Monday to Friday. The lines are fitted linear regressions with x = hours: 7:30 to 15:30 and y = the level of each variable in degrees Celsius and in percentage of relative humidity. School 1 and school 2 are two different groups of schoolchildren. Vertical lines within the figures indicate the days.

increases from morning to afternoon. In contrast to humidity, the dew point increases parallel to indoor air temperature. The highest indoor temperature during school hours was 32.5°C in Yaoundé and 36.6°C in Douala. The highest relative humidity in Yaoundé was 87% during week 1 and the lowest was 55.3% and occurred during week 2. In Douala, the highest relative humidity was 85% and the lowest 53%. In Yaoundé, the highest dew point was at 25.3°C during week 1 and the lowest was at 17.8°C during week 2. Daily outdoor air temperature increases from morning to afternoon, with the highest temperatures of 33.6°C in Yaoundé and 35.6°C in Douala.

Discussion

The present study is both important and needed since data on the impact of heat on self-reported and measured health in Cameroon is largely missing, especially among schoolchildren. Our study is one of the first to provide data on indoor air temperature in schools and on the health impact of heat on schoolchildren in Cameroon. Temperature inside the classroom was very high during the present study and was found associated with health symptoms such as fatigue, headaches, and feeling very hot.

Symptoms of heat exhaustion, including headache, vertigo, fatigue, very hot, slept in class, and thirst were observed among our schoolchildren. These were particularly present during the afternoon and around noon when indoor air temperature and dew point were high. In fact, most people feel comfortable when the indoor air temperature is between 20–27°C with relative humidity ranges from 35–60% (22). In this study, the indoor air temperature exceeded 27°C every afternoon. Most of the time, the temperature in Yaoundé was close to 30°C with an increasing dew point. In Douala, temperatures were greater than 32°C with a high relative humidity close to 70%. This explains why the children felt hot/very hot and reported headaches and fatigue as well as other symptoms. Exposure to high temperature has been associated to illnesses and high morbidity in many studies (1, 8, 10, 23).

A high proportion of our schoolchildren reported that they felt very hot. This is probably because there was no ventilation, no adequate roof, windows, and wall in the

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classrooms. Furthermore, most of the time doors and windows were closed. Sometimes the roof was made of tiles and the tiles were damaged. Moreover, there were more than 80 children in a classroom and their uniforms and shoes were not appropriate for the heat. In addition, schoolchildren do not always drink fluids when they are thirsty because there is no water supply inside the classroom. In fact, the children are forced to sit in the classroom during lessons. They cannot go out for fresh air. The health impact of heat, as described in the present study, has been reported in many other studies (1, 2, 4, 8, 24). Warm environments were related to headaches, feeling bad, and lethargy in a review by Wyon (14). Recently, Parsons described how fatigue, heat stroke, and death were related to extreme heat (25).

A gender difference was observed in the present study. Girls reported a higher prevalence of headaches and feeling very hot overall and in the head than boys did. Girls are probably more vulnerable to high indoor air temperature because of menstruation and body composition. Boys sometimes removed their shirts and rinsed their heads when it was hot (although only during breaks). The girls did not do this. The boys' short haircuts might be protective, while girls have plaited and tight hairstyles. Also, girls had tight uniforms whereas boys had roomy uniforms. Sometimes girls have extra clothes/tee-shirt under their uniform. Girls were heavier than boys, and this might partially explain why they felt very hot more often than the boys did. Gender differences due to heat have been related to adverse health problems in other studies (23).

The higher prevalence of very hot overall and in the head among schoolchildren during week 1 compared to week 2 (Table 1), as well as the difference between week 1 and week 2 in Yaoundé regarding the relationship between indoor temperature and very hot, fatigue, and headaches among schoolchildren, could be due to the fact that school 2 experienced almost no changes in indoor temperature between days in contrast to school 1. This difference could also be due to the higher number of girls in school 1 (56 girls vs 33 boys) compared to school 2 (47 girls vs 38 boys), since more girls felt very hot than did boys.

Body temperature exceeded 37°C in some schoolchildren. This was probably due to extremely high indoor air temperatures, especially during week 1. This likely caused thermal stress. The healthy human body maintains a temperature of approximately 37°C (5). Higher temperatures can cause malfunction of body systems (2, 5, 8), and vulnerability to heat is linked to intrinsic changes in the regulatory system (1, 4, 8). Several studies have reported excess mortality due to heat waves. In 1995, a 13.5% excess in deaths due to heat was reported among children aged 0 to 15 years in London (2, 26, 27).

In the present study, many schoolchildren were absent-minded, had low writing speed, and did not understand the lessons especially in the afternoon and around noon probably because of indoor air temperatures of more than 32°C in classrooms in Yaoundé. High indoor air temperatures and dew points were related to headache, fatigue, and feeling hot and this might have had negative effects on school performance. In fact, the speed of school work decreases for each 1°C increase in indoor air temperature (28). Some classroom studies in the 1960s found that reading speed, reading comprehension, and multiplication performance of schoolchildren were poorer at temperatures of 27–29°C (29). Also, more recent studies found that warm environments affect work performance by increasing spelling, reading, typing, grammatical errors, and a difficulty in thinking clearly and concentrating (11, 14). Creative thinking was worse at 30°C than at lower temperatures in a study of office work (3). Longitudinal data analysis studying hourly and daily symptoms, body measurements, and indoor air temperature measures between days in schools are needed to confirm these results and to disentangle trends within and between days from the association between indoor temperature and health status as well as to properly adjust for confounding factors.

Conclusions

Adverse symptoms such as headache, fatigue, and feeling very hot was found associated with high indoor air temperatures among schoolchildren in Cameroon. Poor school performance was also observed among our schoolchildren during the warmest period of the day. Adequate environmental actions including good ventilation, open doors and windows, and water supplies are needed in schools that experience high heat.

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Conflict of interest and funding

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