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University Students Sport's Activities Assessment in Harsh Weather Conditions

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Abstract**—**This paper addresses the application of physiological status monitoring (PSM) for assessing the impact of harsh weather conditions on sports activities in universities in Saudi Arabia. Real sports measurement was conducted during sports activities such that the physiological status (HR and BR) of five students were continuously monitored by using Zephyr BioHarness^{TM} 3.0 sensors in order to identify the physiological bonds and zones. These bonds and zones were employed as indicators of the associated physiological risks of the performed sports activities. Furthermore, a short yes/no questionnaire was applied to collect information on participants' health conditions and opinions of the applied PSM sensors. The results show the absence of a warning system as a protective aid for the hazardous levels of extremely hot and humid weather conditions that may cause dangerous and fatal circumstances. The applied formulas for estimating maximum HR provides accurate estimations for Maximum Heart Rate (HR_{max}). The physiological results reveal that the performed activities by the participants are considered the highest category (90–100%) in terms of activity intensity. This category is associated with higher HR, BR and physiological risks including losing the ability to control human body behaviors. Therefore, there is a need for immediate intervention actions to reduce the intensity of the performed activities to safer zones. The outcomes of this study assist the safety improvement of sports activities inside universities and athletes performing their sports activities. To the best of our knowledge, this is the first paper to represent a special case of the application of PSM technology for assessing sports activities in universities considering the impacts of harsh weather conditions on students' health and safety.

Keywords**—**PSM, heart rate, HR, breathing rate, BR.

I. Introduction

In recent years, both educational and industrial/construction organizations are becoming fully aware of the safety aspects to enhance the safety conditions of their members. In universities, students are the main focus of the education processes and keeping them safe inside the educational facilities is becoming a high priority. Modern educational organizations provide comprehensive sports programs to the students. Thus, students' health and safety should gain more attention to keep them in a safe environment when considering different sporting activities conducted in harsh weather conditions. At universities, students may perform some activities characterized as heavy and hazardous outdoor activities that expose them to regular heat stress or unsafe conditions, especially under hot and humid weather conditions. Educational organizations such as universities should have proactive actions and protection aids to protect their members.

Students in Arabian Gulf universities are suffering from such extremely hot and humid weather conditions. Arabian Gulf countries are among the hottest in the world in which maximum temperatures can exceed 135 °F (45 °C) and humidity levels may be higher that 90% [17]. In recent years, Arabian Gulf universities provide international programs for foreign students, coming from different countries, who are not familiar with such weather conditions. Different studies addressed the impact of extremely hot and humid weather conditions on the human body, generally in Arabian Gulf countries, with considering different aspects such as the physiological impact of hot weather on construction workers in UAE [2]; and, extremely hot weather on the hydration status of construction and other manual workers in the Middle East [3].

The previous studies that addressed students and employees' accidents in universities and educational organizations mainly focused on those that are related to the students including primary secondary schools [18], [6], [30]-[32], [5], [10], [35] and in universities [9], [11], [8], [36]. However, in the literature, this kind of analysis on the impact of extremely hot weather on students in education organizations such as universities with proposing a quantitative assessment and real measurements is quite limited. The lack of literature on the impacts of harsh weather conditions at members of educational organizations can be explained by the lower heat-related incidents recorded at such institutes in comparison to various industries such as construction [16]. In addition, none of the previous studies addressed the impact of extremely hot and humid weather conditions on universities students in the Arabian Gulf region by utilizing PSM technology. There are a variety of sensors could be used for PSM, however, selecting a sensor for monitoring the physiological status of the human body mainly depends on the applicability, reliability and the validity of the recorded data. Zephyr BioHarness™ 3.0 is one of the most applicable sensors that is applied for PSM purposes [12], [14], [25], [21], [22]. Zephyr BioHarness™ 3.0 sensors have been applied successfully for monitoring the physiological status of the human body for serving different purposes such as sports activities [23], [29], [1]; medical and health purposes [28], [26], [20]; and other industries such as industrial and construction industry [14], [25], [13], [21], [22].

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The ways in which Arabian Gulf universities have been dealing with the impact of extremely hot and humid weather conditions on their students' health and safety have been influenced by a wide range of factors. To enhance, the universities' students performing sports activities under direct sunlight, which may expose them to unsafe conditions as a result of extremely hot and humid weather conditions. Therefore, there is a need for assessing the impact of such unsafe conditions on students' health and safety. The proposed research is aiming to identify the safer physiological bonds and zones of university students while they are performing normal sports activities under extremely hot and humid weather conditions. These bonds and zones are applied to identify whether the participants were exposed to hazardous conditions. A real sports experiment was conducted during sports activities such that the physiological status (Heart Rate (HR) and Breathing Rate (BR)) of five students were continuously monitored using Zephyr BioHarness^{TM} 3 sensors in one of the top universities in Saudi Arabia. In addition, participants' opinions about the utilized sensors were addressed by using a questionnaire.

II. Research Methodology

The proposed research is aiming to answer the questions: Do graduate students in universities perform hazardous sports activates under extremely hot and humid weather conditions? How to monitor the health and safety conditions of graduate students in universities in order to issue warning signs when they are exposed to hazardous conditions? In order to answer the proposed questions, training measurements were conducted on the night of June 4, 2015 (from 07:12 p.m. to 07:47 p.m.), including five students from the subjected university who volunteered to take part in this recording session. The participants, who have the same nationality (Yemeni), were asked to be monitored by Zephyr belts while playing a football game at the university's stadium. The data related to participants' age and body parameters are summarized in Table I.

TABLE I
Training Measurements of Participants

No. Participant	Age	Sex (M/F)	Height (ins)	Weight (Ibs)	Fitness Level
1	33	M	66.14	181.88	5
2	32	M	67.7	165	5
3	29	M	67.7	187.39	5
4	23	M	68	130	5
5	22	M	69.29	160.9	5

Weather conditions of this date were retrieved from "Weatherspark" website [4] based on "King Abdulaziz Air Base (Dhahran International Airport)" records. The proposed measurements were taken between 7 p.m. and 8 p.m., when the maximum temperature is 45°C, the average temperature is 41°C and the minimum temperature is 21°C. Also, the maximum, average and minimum humidity levels were 49%, 21% and 13%, respectively. The hourly average degree of temperature on this day is illustrated in Table II and Fig. 1.

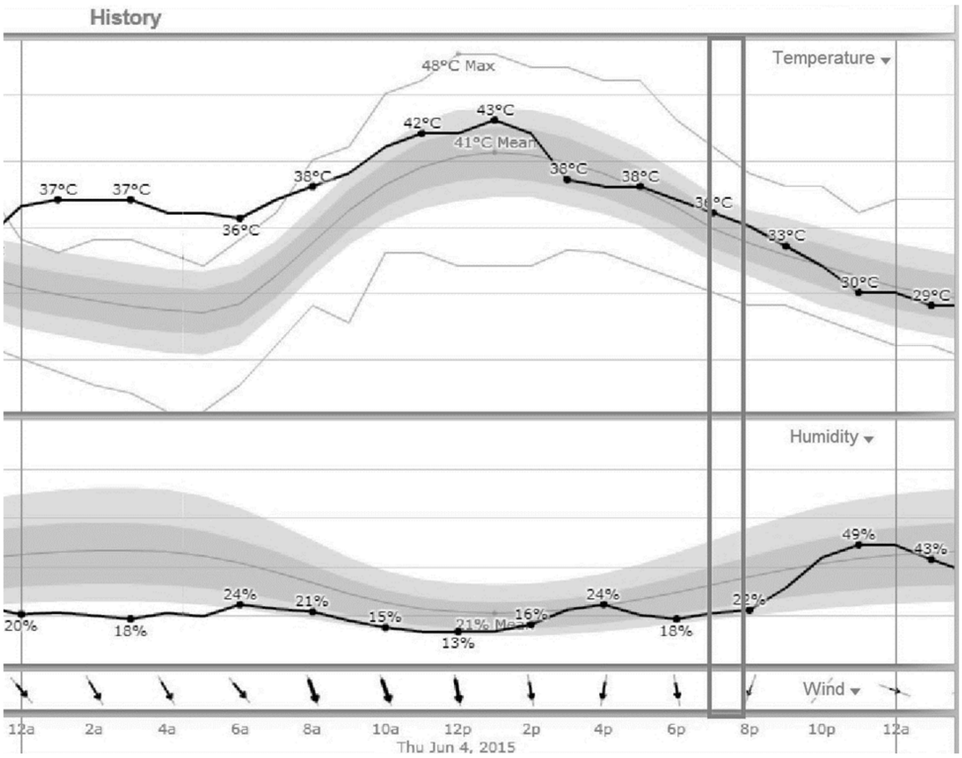

Fig. 1 Weather conditions for training measurements [4]

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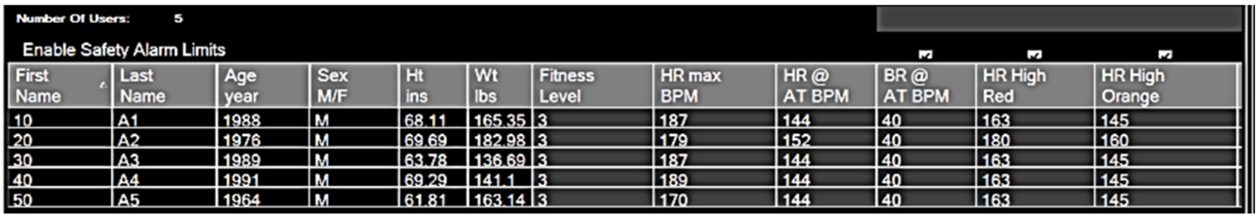
TABLE II
TEMPERATURE AND HUMIDITY OF TRAINING MEASUREMENTS [4]

Time (hr.) A.M.	Avg. Temperature (°C)	Humidity %	Time (hr.) P.M.	Avg. Temperature (°C)	Humidity %
12	37	20	12	42	13
1	37	21	1	43	13
2	37	20	2	42	16
3	37	18	3	38	22
4	36	21	4	38	24
5	36	19	5	38	20
6	36	24	6	37	18
7	37	22	**7**	**36**	**21**
8	38	21	**8**	**35**	**22**
9	39	18	9	33	31
10	41	15	10	32	44
11	42	13	11	30	49

A. Procedures and Data Collection

The proposed method of this research includes real measurements conducted in systematic and organized processes. The measurements process began by preparing the settings for the selected software ("OmniSense Analysis" and "OmniSense Live") used in this study. The preparation process includes updating the Zephyr software in both the computer and sensors using three different software applications, which are "Zephyr Configuration Tool" and "OmniSense Analysis" in addition to "OmniSense Live" such that it is necessary to enter the required data for each participant. These data are related to participants' first and last name; age; sex, height (inches); weight (pounds (lb)); as well, individual fitness level should be identified and entered in the required fields, as shown in Fig. 2.


Number Of Users: 5
Enable Safety Alarm Limits

First Name	Last Name	Age year	Sex M/F	Ht ins	Wt lbs	Fitness Level	HR max BPM	HR @ AT BPM	BR @ AT BPM	HR High Red	HR High Orange
10	A1	1988	M	68.11	165.35	3	187	144	40	163	145
20	A2	1976	M	69.69	182.98	3	179	152	40	180	160
30	A3	1989	M	63.78	136.69	3	187	144	40	163	145
40	A4	1991	M	69.29	141.1	3	189	144	40	163	145
50	A5	1964	M	61.81	163.14	3	170	144	40	163	145

Fig. 2 Required data for OmniSense Live software

The required data for the first six fields are measured directly by asking the participants about their names/ages and by measuring their height and weight. Moreover, the "OmniSense Live" software has a scale from 0 to 10 that is used as an indicator for the fitness level of the participants. In this study, it is assumed that all participants have a normal fitness level, with a score of 5. In addition, fitness level can be calculated by using "OmniSense Analysis" after collecting the data. The other fields (HR_{max}, BR at Rest) were calculated and updated after and/or during recording the data by "OmniSense Analysis". The wireless connection devices (ECHO gate and ECHO gate repeater) allows the sensors to monitor the participant's physiological responses remotely and continuously and over wide area that covers the entire playing area. The ECHO gate and ECHO gate repeater covers a range up to 300 yards, individually i.e. 600 yards in total.

After preparing all the required equipment and software, the measurement gathering is moved to the next stage, which is wearing of the Zephyr belts by participants in such way that it must be comfortable and they can perform their activities normally. Based on the apparatus' user's guide, Zephyr belts consist of three different sensors: (1) HR (ECG) sensor; (2) Breathing sensor; and (3) Accelerometer (see Fig. 3). Two main criteria should be considered in wearing Zephyr belts (tension and position of the belt on participants' body). The Zephyr belts tension should be suitable for human body breathing such that the participant can breathe normally without suffering from shortness of breath as a result of belt tightness. In addition, it is important to position the belt in the center of the area under the participant's armpit with an allowance of around one inch in order to get the optimal signal detection from the sensors. It is necessary to check the signal directly from "OmniSense Live" to make sure that all the sensors are connected to the software and they give the optimal signal.

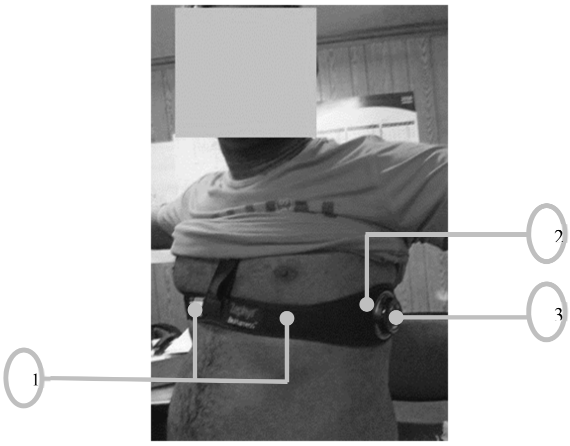


Fig. 3 Zephyr belt sensors

It is necessary to collect information about the participants' health conditions by asking them direct questions. In addition, participants' opinions about Zephyr belts were assessed directly by a few questions describing their opinions.

III. RESULTS

Training measurements included the different physical parameters and ages of the five participants, as illustrated in Table I. The participants were asked seven questions in order to identify whether they have any health problems, in addition to assessing their opinions about how they feel when they wear Zephyr belts. Fig. 4 summarizes their responses.

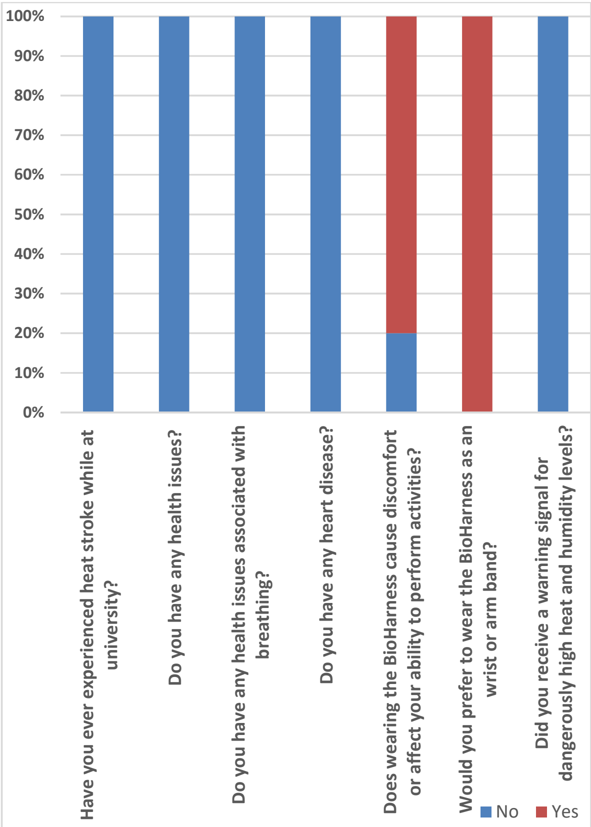


Fig. 4 Summary of participants' responses in training measurement

The results of the applied questionnaire, shown in Fig. 4, reveal that none of the participants have health problems, especially with breathing difficulties and heart disease. Four of the participants stated that the utilized sensors did not cause them any discomfort. Further, all participants preferred if the applied sensors were manufactured to be worn around the wrist or upper arm. Importantly, none of the participants received any warning signs when the temperature and humidity reached dangerously high levels, which means there is no a proactive warning system to protect students from harsh weather conditions.

The preliminary data were recorded during a football match played on the night of June 4, 2015, where the data recording starts at 07:12 p.m. and continued to 07:47 p.m. (see Appendix 1). It is noticed that there is some fluctuation in the first one minute such that HR value reached to zero. This non-reasonable variability in HR and BR values during the first minutes is resulted from the time that it takes to adjust Zephyr belts to be fitted to the participants' body in addition to the time it takes to connect the sensors to the Echo Gate correctly. Therefore, the data that is recorded in the first minutes was eliminated before analyzing the data. For these reasons, a similar step is performed to eliminate the recorded data during the first minutes of each subject. Fig. 5 represents a sample of the recorded the HR and BR data of subject 4. Fig. 6 illustrates the recorded HR and BR data of subject 4 after removing data related to the first minutes.

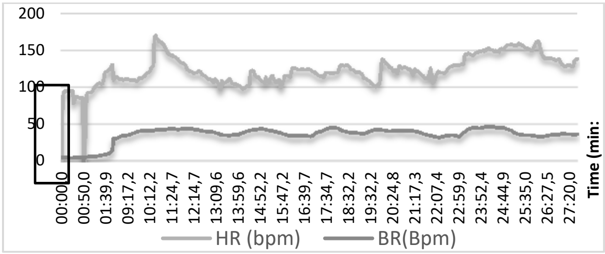


Fig. 5 Hourly HR and BR plot for subject 4 of the training measurements

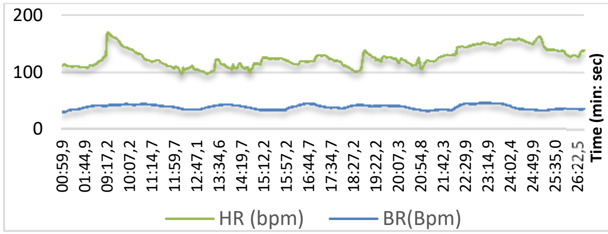


Fig. 6 Recorded data of the fourth subject's HR and BR after removing the first minute

A. Two-Tailed Grubbs' Test

Grubbs' test is a statistical test that is applied for removing the outliers from a set of data that have the tendency to follow a normal distribution [15]. The distribution of human HR and BR tends to be normally distributed. Therefore, Grubbs' test is applied to eliminate the outliers' points from the recorded data.

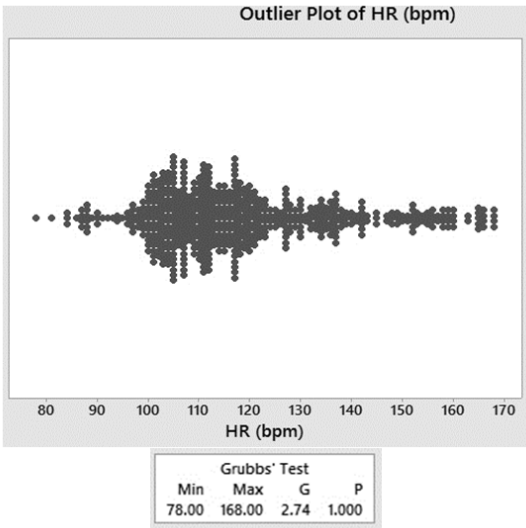


Fig. 7 Two-tailed Grubbs' test results for the first subject HR

Two-tailed ("smallest and largest value is an outlier") Grubbs' test is conducted by using "Minitab® 17.1.0" software with significant level (α=0.05). Appendix 3 includes the Minitab's outputs of Two-tailed Grubbs' test for each subject. Minitab outputs for the first subject HR and BR reveals that there are no outliers in the recorded HR data, as illustrated in Fig. 7. The same result appears for the BR of the first subject, as illustrated in Fig. 8.

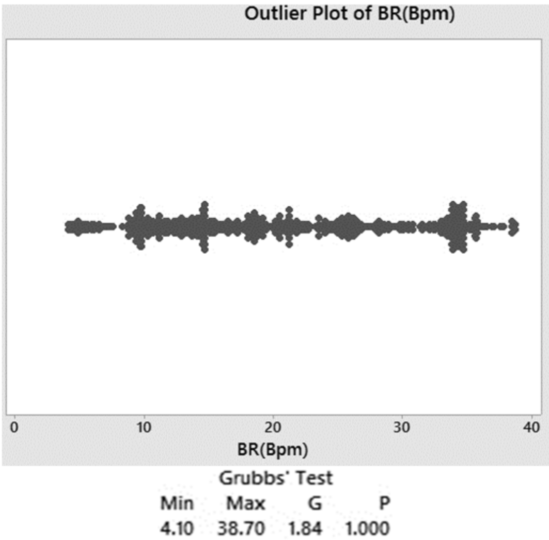


Fig. 8 Two-tailed Grubbs' test results for the first subject BR before removing outliers

The previous steps are applied for the remaining four subjects such that the first minutes of the recorded data are first eliminated, and then outliers test is applied. The results of the Two-tailed Grubbs' test for HR and BR for each participant are summarized in Table III.

In this study, different formulas are introduced to estimate the various required variables in order to calculate the acceptable HR and BR physiological bounds and HR zones for the conducted measurements, as explained in the following:

- Expected maximum heart rate (HR_{max}).
- Acceptable HR and BR physiological bounds.
- Target heart rate (THR).
- Heart rate reserve (HRR).
- Maximal oxygen uptake (VO_{2max}).
- Desired and estimated activity intensity level.
- Resting Heart Rate.
- Maximum heart rate (HR_{max})

In the literature, there are several valid formulas that can be used for estimating the maximum heart rate considering different ages. In this study, the most accurate formula [34], [21] that had been applied successfully in construction applications are applied to estimate HR_{max}, as the following:

$$HR_{max} = 203.7/(1 + \exp(\,0.033 \times (\text{age} - 104.3)\,)\,) \quad (1)$$

where, HR_{max} denotes to expected maximum HR.

TABLE III
TWO-TAILED ("SMALLEST AND LARGEST VALUE IS AN OUTLIER") HR GRUBBS' TEST RESULTS

Type of Measurement	Subject #	HR / BR	P-Value	Decision	No. Outliers	From (min)	To (min)
		Recording starts at (07:12:47 P.M.) / Recording Time (00:34:24.9)					
	1	HR	1.000	None	0	1	34.42
		BR	1.000	None	0		
		Recording starts at (07:12:47 P.M.) / Recording Time (00:32:52.4)					
	2	HR	1.000	None	0	1	32.87
		BR	1.000	None	0		
		Recording starts at (07:12:47 P.M.) / Recording Time (00:29:50)					
Training Measurements	3	HR	1.000	None	0	1	29.83
		BR	1.000	None	0		
		Recording starts at (07:12:47 P.M.) / Recording Time (00:27:37.6)					
	4	HR	1.000	None	0	1	27.63
		BR	0.021	Outlier	22		
		Recording starts at (07:12:47 P.M.) / Recording Time (00:24:02.7)					
	5	HR	1.000	None	0	1	24.05
		BR	1.000	None	0		

- Target heart rate (THR).

$$THR = \left((HR_{max} - HR_{min.rest}) \times intesity\%\right) + Avg.HR_{rest} \quad (2)$$

- Heart rate reserve (HRR).

$$HRR = Predicted\ HR_{max} - Avg.HR_{rest} \quad (3)$$

- Body mass index (BMI)

$$BMI = \frac{Weight\ (kg)}{(Height\ (m))^2} \quad (4)$$

- Body fat percentage (%Fat)

$$\%Fat = (1.20 \times BMI) + (0.23 \times Age) - (10.8 \times Gender) - 5.4 \quad (5)$$

- Resting HR

During training measurements, the participants had not resting session; therefore, resting HR and BR were retrieved from published references. Resting heart rate for healthy young men whose ages between 24 to 32 years is 68 ± 6 BPM [24] where BR is 19.4 ± 4 [7].

- Acceptable HR and BR physiological ranges.

$$HR_{min} = HR_{\min resting\ session} - \left(2 \times HR_{SD\ resting\ session}\right) \quad (6)$$

$$HR_{max} = HR_{\max working\ session} + (2 \times HR_{SD\ working\ session}) \quad (7)$$

$$BR_{min} = BR_{\min resting\ session} - \left(2 \times BR_{SD\ resting\ session}\right) \quad (8)$$

$$BR_{max} = BR_{\max working\ session} + (2 \times BR_{SD\ working\ session}) \quad (9)$$

Tables IV and V summarize the acceptable ranges of the HR and BR for the participants.

TABLE IV
HR ACCEPTABLE RANGES FOR THE TRAINING MEASUREMENTS

Subject	HR_{min} resting session	HR_{SD} resting session	HR_{max} Training	HR_{SD} Training	Acceptable Range (BPM)	
					HR_{min}	HR_{max}
1			168	18.19	56	204
2			179	23.98	56	227
3	68	6	171	22.99	56	217
4			171	17	56	205
5			185	23.38	56	232

TABLE V
BR ACCEPTABLE RANGES FOR TRAINING MEASUREMENTS

Subject	BR_{min} resting session	BR_{SD} resting session	BR_{max} Training	BR_{SD} Training	Acceptable Range (BPM)	
					BR_{min}	BR_{max}
1			38.7	9.563	11.4	57.8
2			41.2	8.453	11.4	58.1
3	19.4	4	38.5	7.095	11.4	52.7
4			46.3	3.95	11.4	54.2
5			47	6.825	11.4	60.7

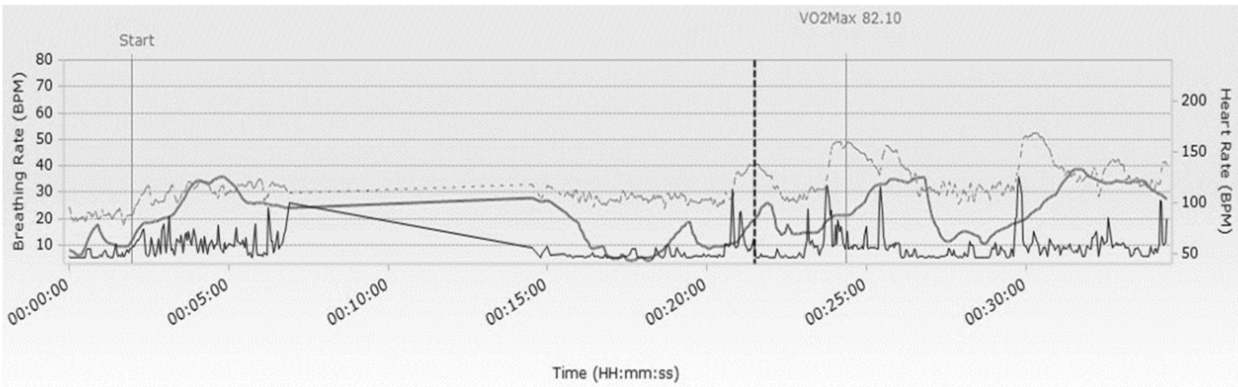


Fig. 9 Maximum oxygen uptake level for the first participant in training measurements

B. Acceptable HR Physiological Zones

Acceptable HR physiological zones are calculated at the desired activity intensity (60: 70 %), as described in Table IX. This activity intensity level is suitable for the human body to perform sporting activities without any harmful risks that may affect an individual's health and safety. Quantitative assessment for the HR of participants and identifying the acceptable HR physiological bounds for each participant provide a good indicator about the activity intensity zone, and consequently, the impact of weather conditions and their performance. Table VI illustrates the acceptable HR physiological bounds for each of the participants.

The physiological parameters HR and BR are used as an indicator for the impact of weather conditions on participants' health and safety such that the participants will be in high risks and exposed to heat-related illnesses when their HR and BR values exceed the physiological thresholds. Based on the calculated physiological thresholds, the percentage of records exceeding these thresholds can be identified, as illustrated in Table VII and Fig. 9.

C. Maximum Oxygen Uptake ($VO_{2_{max}}$) Level

Maximum oxygen uptake ($VO_{2_{max}}$) level is calculated by applying two methods, one of them is by using Zephyr (OmniSense Analysis V3.9.6) directly, as illustrated in Fig. 9.

Fig. 9 shows the $VO_{2_{max}}(\frac{mL}{Kg \times min})$ level for Subject 1 in the training measurements, where it represents the output of the "Treadmill test" that is retrieved from the OmniSense Analysis V3.9.6 software. Three different types of data are utilized in the "Treadmill test". These data are illustrated by different lines where the continuous and dashed red lines represent the BR in breaths per minute and HR in beats per minute, respectively. In addition, the black continuous line denotes the activity level of the participants which are measured by Vector Magnitude Units (VMU). Another method for calculating maximum oxygen uptake (VO_{2max}) was addressed in the published research, where it is calculated based on the result of the maximum heart rate during the training session HR_{max} divided by the minimum heart rate during the rest session HR_{rest}, as shown in the formula [33]:

$$VO_{2max} \approx 15.0\ (\frac{mL}{Kg\times min}) \times \frac{HR_{max}}{HR_{min.rest}} \qquad (10)$$

In this study, we also proposed that VO_{2max} can be calculated by multiplying the ratio between maximum heart rate in training session HR_{max} and average heart rate during rest session $Avg.HR_{rest}$, as shown in:

$$VO_{2}{}^{*}_{max} \approx 15.0\ (\frac{mL}{Kg\times min}) \times \frac{HR_{max}}{Avg.HR_{rest}} \qquad (11)$$

- Metabolic equivalents (METs).

$$\text{METs} = \frac{VO_{2max}}{3.5\ mL.Kg^{-1}.min^{-1}} \qquad (12)$$

TABLE VI
ACCEPTABLE PHYSIOLOGICAL ZONES OF TRAINING MEASUREMENTS

Subject	BMI	%Fat	Predicted	Resting Session		Training				Measured/ Predicted %	Acceptable HR Ranges		HR zones	
				Mean	SD	Min	Mean	SD	Max		Min	Max	Lower	Upper
1	29.2	26.5	186	68	6	54	118	18	168	90	56	204	144	159
2	25.3	21.5	187	68	6	53	130	24	179	96	56	227	157	175
3	28.7	25.0	188	68	6	55	118	23	171	91	56	217	152	168
4	19.8	12.8	191	68	6	52	126	17	171	90	56	205	144	159
5	23.6	17.1	191	68	6	52	135	23	185	97%	56	232	160	178

TABLE VII
PERCENTAGE OF RECORDS EXCEEDING PHYSIOLOGICAL THRESHOLDS

Subject	% Exceeding HR ranges	% Exceeding BR ranges	% Exceeding HR zones
1	0	19	3
2	0	5	2
3	0	5	1
4	0	5	3
5	0	0	5

D. Desired, Actual and Estimated Activity Intensity

Desired activity level as it is addressed by [19], [21] should be within 60-70% of the activity intensity percentage i.e. zone 2 in order to make the participants performing their tasks with high levels of productivity under light intensity. Five different zones are listed from the lowest to the highest intensity in Table IX, which are used as an index for assessing the activity intensity level.

TABLE VIII
ACTUAL AND EXPECTED MAXIMUM OXYGEN UPTAKE LEVEL AND METABOLIC EQUIVALENTS (METS) OF TRAINING MEASUREMENTS

Subject	Actual VO_{2max}	$HR_{\text{min at rest}}$	$Avg.HR_{rest}$	HR_{max}	VO_{2max}	$VO_{2}{}^{*}_{max}$	Actual METs	METs	METs*
1	82.1	54	68	168	47	37	23	13	11
2	68.68	53	68	179	51	39	20	14	11
3	41.83	55	68	171	47	38	12	13	11
4	31.09	52	68	171	49	38	9	14	11
5	25.72	52	68	185	53	41	7	15	12

TABLE IX
DIFFERENT ACTIVITY INTENSITY ZONES

Zone Index	Activity Intensity %	Objective Measures	Color Index	Zone Intensity	Description
1	[50:60%]	< 1.6 METs < 20% VO_{2max}	Yellow	Sedentary	Related to sitting based activities such as reading, watching, driving car… etc., considered as a safe and conformable HR zone for workers [27], [21].
2	[60:70%]	1.6<3METs 20< 40% VO_{2max}	Orange	Light	Light activities and duties provide high productivity level [21].
3	[70:80%]	3< 6 METs 40 < 60% VO_{2max}	Coral	Moderate	Hard normal work with achieving a good performance level and provide positive pressure [21].
4	[80:90%]	6< 9 METs 60 < 85% VO_{2max}	Light Red	Vigorous	Physical activities such as heavy lifting which cause difficulty in breathing and high levels of physiological stress [27]. Considered as an unsafe zone [21].
5	[90:100%]	≥ 9 METs ≥ 85% VO_{2max}	Dark Red	High	The most hazardous zone in which the individuals cannot control their behavior and require immediate medical attention to return to lower zones [21].

Activity intensity can be calculated by different methods. The first method applied in this study is the activity intensity zones index [27], which is used to identify the activity intensity level based on two variables VO_{2max} and METs. For identifying in which zone the participants are in during the training session, it is required to calculate both VO_{2max} and METs of each participant, as illustrated in Table IX.

By using the activity intensity index [27], we can identify in which category, the performed activities are related. For instance, for Subject 1, the calculated maximum oxygen uptake (VO_{2max}) and metabolic equivalents (METs) are 35 and 10, respectively. These two values of the METs and

VO_{2max} gives a significant indication that the participants performed high intensity activities (dark red zone, which is the highest intensity in the scale) (see Table IX). The same procedures are followed for the other values of VO_{2max} and METs of each participant in the study. Table X summarizes the results of the actual and calculated activity intensity zones.

TABLE X
ACTUAL AND CALCULATED ACTIVITY INTENSITY OF THE TRAINING MEASUREMENTS

Subject	Actual Zone			Calculated Zone			Calculated Zone*		
1	5	] 90:100%]	High Intensity	5	] 90:100%]	High Intensity	5	] 90:100%]	High Intensity
2	5	] 90:100%]	High Intensity	5	] 90:100%]	High Intensity	5	] 90:100%]	High Intensity
3	5	] 90:100%]	High Intensity	5	] 90:100%]	High Intensity	5	] 90:100%]	High Intensity
4	5	] 90:100%]	High Intensity	5	] 90:100%]	High Intensity	5	] 90:100%]	High Intensity
5	5	] 90:100%]	High Intensity	5	] 90:100%]	High Intensity	5	] 90:100%]	High Intensity

IV. DISCUSSION AND CONCLUSION

The results of the applied questionnaire revealed that the university students do not have any warning system with cautionary notifications when weather conditions reach dangerously high levels which may have a significant impact on their health and safety. Adopting such system in Saudi Arabia will help in protecting athletes from suffering from overexertion and heat-related illnesses. Furthermore, the application of (3) for estimating maximum HR provides an accurate estimation. This result supports the argument that (3) provides the most accurate estimation for HR_{max}, where the minimum value of (Measured/Predicted %) ratio is 90%. A similar conclusion was addressed by [34], [21]. Moreover, the results indicated that HR records did not exceed the acceptable HR ranges. This gives a clue that the participants were not exposed to cardiovascular overload. However, there were some indications of the participants' exposure to high intensity levels, such that all participants HR records surpassed the acceptable HR zones. The results derived from detecting BR records confirm that participants were exposed to overexertion due to high intensity activities under harsh weather conditions. Further, analysis was conducted to identify the estimated and actual activity intensity levels under harsh weather conditions. All participants were exposed to the highest intensity level that is considered as the most hazardous activity zone. The resulted risk of performing sport activities under such conditions can impose substantial risks to health such as losing the ability to control body core temperature, and consequently stopping sweating, which leads to confusion, consciousness disturbance, and convulsions. Hence, it is important to provide a heat stress guideline to manage heat-related risks for students who perform sporting activities in harsh weather conditions.

This research highly recommends conducting more research investigating students' health and safety in harsh weather conditions. Importantly, this research triggers the need for a heat stress guideline that provides a safer educational environment, particularly in Arab Gulf Countries.

REFERENCES

[1] Atrash, A., Mower, E., Shams, K., & Mataric, M. J. (2011). Recognition of Physiological Data for a Motivational Agent. AAAI Spring Symposium: Computational Physiology. Stanford, CA.

[2] Bates, G. P., & Schneider, J. (2008). Hydration status and physiological workload of UAE construction workers: A prospective longitudinal observational study. J Occup Med Toxicol, 3(21), 4-5.

[3] Bates, G. P., Miller, V. S., & Joubert, D. M. (2009). Hydration status of expatriate manual workers during summer in the Middle East. Annals of occupational hygiene, 54(2), 137–143.

[4] Beautiful Weather Graphs and Maps – Weather Spark. (2015). Retrieved August 12, 2015, from Weatherspark.com: https://weatherspark.com

[5] Campbell, S. (2012). Supporting mandatory first aid training in primary schools. Nursing Standard, 27(6), 35-39.

[6] Chau, N., Predine, R., Benamghar, L., Michaely, J. P., Choquet, M., & Predine, E. (2008). Determinants of school injury proneness in adolescents: a prospective study. Public health, 122(8), 801-808.

[7] Cichero, J. A., & Murdoch, B. E. (2006). "Dysphagia: foundation, theory and practice". West Sussex, England: John Wiley & Sons.

[8] Clapp, J. D., Johnson, M., Voas, R. B., Lange, J. E., Shillington, A., & Russell, C. (2005). Reducing DUI among US college students: Results of an environmental prevention trial. Addiction, 100(3), 327-334.

[9] Crowe, J. W. (1995). Safety values and safe practices among college students. Journal of Safety Research, 26(3), 187-195.

[10] Denny, S., Farrant, B., Cosgriff, J., Harte, M., Cameron, T., Johnson, R., & Ameratunga, S. (2013). Forgone health care among secondary school students in New Zealand. Journal of primary health care, 5(1), 11-18.

[11] Fennell, R. (1997). Health behaviors of students attending historically black colleges and universities: results from the National College Health Risk Behavior Survey. Journal of American College Health, 46(3), 109-117.

[12] Gatti, U. C., Migliaccio, G. C., & Schneider, S. (2011). Wearable physiological status monitors for measuring and evaluating worker's physical strain: preliminary validation. International Workshop on Computing in Civil Engineering 2011, (pp. 194-201). Miami, Florida, United States.

[13] Gatti, U. C., Migliaccio, G. C., Bogus, S. M., & Schneider, S. (2014a). An exploratory study of the relationship between construction workforce physical strain and task level productivity. Construction Management and Economics, 32(6), 548-564.

[14] Gatti, U., Migliaccio, G., Bogus, S., & Schneider, S. (2012a). Using Wearable Physiological Status Monitors for Analyzing the Physical Strain-Productivity Relationship for Construction Tasks. International Conference on Computing in Civil Engineering 2012, (pp. 577-585). Clearwater Beach, Florida, United States.

[15] Grubbs, F. E., & Beck, G. (1972). "Extension of sample sizes and percentage points for significance tests of outlying observations". Technometrics, 14(4), 847-854.

[16] Herrmann, M. A., & Rockoff, J. E. (2012). Does menstruation explain gender gaps in work absenteeism? Journal of Human Resources, 47(2), 493-508.

[17] Joubert, D., Thomsen, J., & Harrison, O. (2011). Safety in the heat: A comprehensive program for prevention of heat illness among workers in Abu Dhabi, United Arab Emirates. American journal of public health, 101(3), 395-398.

[18] Kann, L., Brener, N. D., & Allensworth, D. D. (2001). Health education: Results from the school health policies and programs study 2000. Journal of School Health, 71(7), 266-278.

[19] Karvonen, M. J. (1957). "The effects of training on heart rate. A longitudinal study". Ann Ned Exp Biol Fenn, 35, 307-315.

[20] Kokonozi, A., Astaras, A., Semertzidis, P., Michail, E., Filos, D., Chouvarda, I., Grossenbacher, O., Koller, J.-M., Leopoldo, R., Porchet, J.-A., Correvon, M., Luprano, J., Sipila, A., Zamboulis, C., & Maglaveras, N. (2010). Development and clinical evaluation of a

physiological data acquisition device for monitoring and exercise guidance of heart failure and chronic heart disease patients. Computing in Cardiology, IEEE, (pp. 1099-1102). Belfast.
[21] Lee, W., & Migliaccio, G. C. (2014). Field Use of Physiological Status Monitoring (PSM) to Identify Construction Workers' Physiologically Acceptable Bounds and Heart Rate Zones. In Computing in Civil and Building Engineering, 1037-1044.
[22] Lee, W., Migliaccio, G. C., Lin, K. Y., & Russo, F. (2015). Lessons learned from using bio-and environmental sensing in construction: A field implementation. 5th International/11th Construction Specialty Conference. Vancouver, British Columbia.
[23] Lerer, S. J., Tieniber, E. B., & Smith, J. M. (2009-2010). Building a wireless ice hockey personnel management system. Pennsylvania, US: University of Pennsylvania, PA.
[24] Levy, W. C., Cerqueira, M. D., Harp, G. D., Johannessen, K. A., Abrass, I. B., Schwartz, R. S., & Stratton, J. R. (1998). "Effect of endurance exercise training on heart rate variability at rest in healthy young and older men". The American journal of cardiology, 82(10), 1236-1241.
[25] Migliaccio, G., Teizer, J., Cheng, T., & Gatti, U. (2012). Automatic Identification of Unsafe Bending Behavior of Construction Workers Using Real-Time Location Sensing and Physiological Status Monitoring. In Proceedings of Construction Research Congress, 633-642.
[26] Myers, L. J., & Downs, J. H. (2009). Parsimonious identification of physiological indices for monitoring cognitive fatigue. Foundations of Augmented Cognition. Neuroergonomics and Operational Neuroscience. Springer Berlin Heidelberg.
[27] Norton, K., Norton, L., & Sadgrove, D. (2010). Position statement on physical activity and exercise intensity terminology. Journal of Science and Medicine in Sport, 13(5), 496-502.
[28] Pantelopoulos, A., & Bourbakis, N. (2009). A health prognosis wearable system with learning capabilities using NNs. Tools with Artificial Intelligence, 2009. ICTAI '09. 21st International Conference, IEEE, (pp. 243 - 247). Newark, NJ.
[29] RW Wilson, I. I., Reynolds, K., & Snyder, A. C. (2011). Use of a Physiological Monitoring System to Determine Ventilatory Threshold. The Journal of Strength & Conditioning Research, 25, S113.
[30] Salminen, S., Lounamaa, A., & Kurenniemi, M. (2008). Gender and injury in Finnish comprehensive schools. Accident Analysis & Prevention, 40(4), 1267-1272.
[31] Teevale, T., Denny, S., Percival, T., & Fleming, T. (2013). Pacific secondary school students' access to primary health care in New Zealand. The New Zealand Medical Journal (Online), 126(1375).
[32] Ungaro, J. F., De Hoyos, G. H., & Enders, J. (2010). Teachers opinions, beliefs and attitudes regarding accidents and their prevention. Injury Prevention,16 (Suppl 1), A193-A193.
[33] Uth, N., Sørensen, H., Overgaard, K., & Pedersen, P. K. (2004). "Estimation of VO2max from the ratio between HRmax and HRrest–the heart rate ratio method". European journal of applied physiology, 91(1), 111-115.
[34] Wohlfart, B., & Farazdaghi, G. R. (2003). "Reference values for the physical work capacity on a bicycle ergometer for men–a comparison with a previous study on women". Clinical physiology and functional imaging, 23(3), 166-170.
[35] Younis, J. R., & El-Abassy, A. (2015). Primary teachers' first aid management of children's school day accidents: Video-assisted teaching method versus lecture method. Journal of Nursing Education and Practice, 5(10), 60.
[36] Yufeng, M., & Xudong, Y. (2015). Researches on Safety Management of Universities Environmental Engineering Laboratory. Guangdong Chemical Industry, 9, 125.