International Journal of Occupational and Environmental Safety

Health risks in tropical climate agriculture: a set of case studies of sugarcane workers

B. Barkokébas Jr.[a], E.M.G. Lago[b], A.R.B. Martins[c], T. Zlatar[d], F.M. da Cruz[e], B.M. Vasconcelos[f], F. M. Campos[g], C. R. Campos[h]

[a]Laboratory on Occupational Safety and Hygiene (LSHT), Polytechnic School (POLI) of the University of Pernambuco (UPE), Recife, BR (beda.jr@upe.br) ORCID: 0000-0003-3130-3277. [b]Laboratory on Occupational Safety and Hygiene (LSHT), Polytechnic School (POLI) of the University of Pernambuco (UPE), Recife, BR (eliane.lago@upe.br) ORCID: 0000-0003-0987-3492. [c]Laboratory on Occupational Safety and Hygiene (LSHT), Polytechnic School (POLI) of the University of Pernambuco (UPE), Recife, BR (ana_rosamartins@hotmail.com) ORCID: 0000-0003-4013-3011. [d]Laboratory on Occupational Safety and Hygiene (LSHT), Polytechnic School (POLI) of the University of Pernambuco (UPE), Recife, BR (tomi.zlatar@poli.br) ORCID: 0000-0002-8915-908X. [e]Laboratory on Occupational Safety and Hygiene (LSHT), Polytechnic School (POLI) of the University of Pernambuco (UPE), Recife, BR (felipemendeslsht@poli.br) ORCID: 0000-0002-0163-465X. [f]Laboratory on Occupational Safety and Hygiene (LSHT), Polytechnic School (POLI) of the University of Pernambuco (UPE), Recife, BR (bianca.vasconcelos@upe.br) ORCID: 0000-0002-5968-9581. [g]Ergonomic Institute Ltda, Goiania, BR (felipecampos2410@gmail.com). [h]Ergonomic Institute Ltda, Goiania, BR (carloscampos2410@gmail.com).

Article History

Received 27 June 2019
Accepted 30 October 2019
Published 15 November 2019

Keywords

Occupational health
Hot thermal environment
Heat stress
Sugarcane agroindustry

DOI:
10.24840/2184-0954_003.003_0005

ISSN:
2184-0954

Type:
Research Article

Open Access
Peer Reviewed

Abstract

The objective of this work was to investigate on safety and health risks to which tropical agricultural workers are exposed, mainly in relation to heat stress. In total, five workers from the sugarcane industry were assessed through the Life Quality Questionnaire, and four through measuring their body composition, heart rate and hydration status. Meteorological data on air temperature, relative humidity and air movement were gathered through a nearby metrological station. The two analyzed sugarcane activities were found to be of moderate physical activity, and therefore less consuming than the activity of sugarcane cutters. The work-rest periods were found to be appropriated, and the work without repetitive movements. The workers involved in agricultural activities should always evaluate the thermal environment conditions and appropriate their working activities and stay well hydrated in order to minimize heat stress risk.

1. INTRODUCTION

Exposure to hot thermal environment is a significant risk factor present indoor in all seasons (foundries, steel mills, bakeries, smelters, glass factories, and furnaces, and highly humid laundries, restaurant kitchens, and canneries) and outdoor during the summer season (in occupations such as road repair, marine, army, agriculture, forestry, mining, factory work, construction work, among summer sport athletic disciplines and related occupations) (Canadian Centre for Occupational Health & Safety 2016). Outdoor exposure to hot is of particular interest for regions near the Equator where the temperatures are high year round with exceptions of high mountains. Further on, overall global temperatures show a fast increasing trend during the past decades (Carlowicz n.d.).

The human body is always working toward maintaining homeostasis, which for the core temperature is approximately 37°C (Saladin and Miller 1998). Intensive exercise increase heat

production, requiring increases in skin blood flow and sweating (Havenith 2005). As sweat evaporates from the skin it removes some thermal energy from the body and re-establishes the body's heat balance (Havenith 2005; Saladin and Miller 1998). If the water and electrolytes lost through sweating are not replaced, the resulting reduction in plasma volume will eventually create further challenge to cardiovascular homeostasis (Havenith 2005). Dehydration results in increased physiological strain as measured by core temperature and heart rate, decreased blood volume, reducing central venous pressure and cardiac output (Tribuzi and Laurindo 2016).

The rate of sweat evaporation also depends on air movement and air relative humidity. In highly humid environments, the air is already saturated with water, making sweat response much less effective, dripping instead of evaporating, and therefore providing lower cooling. With intensive work, with higher heat production and reduced cooling, the core body temperature can get dangerously high (Saladin and Miller 1998; Tribuzi and Laurindo 2016).

Heat exposure can further on lead to a number of illnesses: heat edema, heat rashes, heat cramps, heat exhaustion, heat syncope and heat stroke; and with aggravation in some cases lead to death (Canadian Centre for Occupational Health & Safety 2016; Jacklitsch et al. 2016).

The North-East part of Brazil with its tropical climate (with mean annual air temperatures ≈25°C and during the sugarcane growing period with relative humidity of 80 to 85%), offers ideal conditions for sugarcane production (NETAFIM n.d.). In Brazilian North-East sugarcane plantations, mechanized harvesting is hampered by mountainous relief (ONG Repórter Brasil n.d.). For that reason, manual sugarcane workers still predominate, facing high temperatures, high relative humidity and high physical exertion.

While there are a number of studies conducted on manual sugarcane cutters (García-Trabanino et al. 2015; Reis 2014; Souza, Filho, and Silva 2012; Wesseling et al. 2016), no studies were found on other working activities in the sugarcane industry, like loading or collecting prune canes. Other most common working are done in same high temperature environmental conditions and exert physical activity of preparing the already cut sugarcane, carry it and loading it into the trucks (types of working activities in Latino America known as "atrelhador" and "bituqueiro". Only in the period from 2004 to 2009, 23 sugarcane workers died from excessive physical exertion (Alves 2006; ONG Repórter Brasil n.d.).

Nevertheless, there is a need to investigate on safety and health risks to which tropical agricultural workers are exposed, mainly in relation to heat stress. Therefore, the aim of this study is to apply a broad range of measurements in order to contribute with new information on safety and health risks in the sugarcane industry.

2. MATERIALS AND METHODS

2.1. General data

The experiments were conducted in the sugarcane industry in the Zone of Mata South, state of Pernambuco, Brazil. All the documents were in Portuguese language. All the workers pass periodical medical examinations conducted by the industrial medical doctor. The workers which participated in the study, were fully informed of all details of the experimental procedures, the nature and purpose of the experiment, as well as the possible discomforts and risks involved discomforts. A written consent to participate in the experiment was read and signed by all workers which before the experiments started.

In Table 1 is shown the outside environmental conditions at near the measured location, gathered by the National Institute of Meteorology (INMET), station of meteorology of Palmares, Pernambuco, Brazil. The tests were conducted during two working days, evaluating the workers W1 and W2 during the first day and W3 and W4 during the second day.

Table 1. Outside air temperature, relative humidity and air velocity data from the measuring days

	Day	06:00 hs	11:00 hs	13:00 hs	17:00 hs
Mean temperature (°C)	1	17.9	23.5	26.9	30.2
	2	21.2	24.3	25.8	28.2
Mean Relative Humidity (%)	1	94	80	64	49
	2	93	83	79	55
Mean Air velocity (m/s²)	1	1.2	1.2	2.0	3.7
	2	0.6	3.1	3.8	5.7

2.2. Workers and work organization

Four rural (sugarcane) male workers (two with one type of activity and two with another) were selected with individual characteristics of evaluated workers are illustrated in the Table 2.

Table 2. Individual characteristics of evaluated workers

	W1			W2			W3			W4		
Time (hs)	I 05:50	II 11:19	III 16:01	I 05:54	II 11:17	III 16:00	I 06:02	II 11:33	III 16:12	I 06:06	II 11:34	III 16:13
Age (years)		35			27			32			23	
Height (cm)		166			173			176			172	
Weight (kg)	74.3	74.1	71.5	73.5	74.5	75.2	63.3	66.1	65.0	88.8	89.5	84.6
BMI (kg/m²)	27.0	26.9	25.9	24.6	24.9	25.1	20.4	21.3	21.0	30.0	30.2	28.6

Workers spent their time in sugarcane plantation, exposed to high air temperatures, high radiant temperature and high relative humidity, conducting moderate physical work. The official work-rest regime was 5:1, with prescribed start at 6:00 am, an interval for lunch at 11:00 pm, and restarting activities from 1:00 to 6:00 pm. The experiments were conducted during a normal working day, with the subjects performing the usual tasks.

The workers W1 and W2 were rural workers with activity 1 (Portuguese “atrelhador”), participating on the first trial day.

The activities are performed to harness and unhook sugarcane trailers from trucks to tractors and vice versa (illustrated in Figure 1). They also conduct loadings and pruning of cane. The worker carries out the lashing of cane cargo in the truck or in the trailers, by means of ropes thrown over the load (illustrated in Figure 2). They also prune the cane, which passes the trailer in order to avoid accidents on the road during the route.

Figure 1. Unhooking sugarcane trailers from the truck to tractors (working activity 1)

Figure 2. Lashing of cane cargo in the truck or in the trailers, by means of ropes thrown over the load (working activity 1)

The workers W3 and W4 were rural workers with activity 2 (Portuguese “bituqueiro”), participating on the second trial day.

The activities consist of collecting the cut cane left for mechanized loading (conventional loader orbell loader);collect the cane (illustrated in Figure 3) which spread on the filling fronts and were lost during mechanized loadings of cane; they follow the loader and manually pick up the cane, throwing them on parallel cane bunches, forming new filling fronts (illustrated in Figure 4).

Figure 3. Collecting cut cane left for mechanized loading working activity 2)

Figure 4. Forming new filling fronts from cut cane (working activity 2)

2.3. Equipment

The body composition was measured with the Body Composition Monitor Tanita BC-1000. The data was stored on the device, later on transferred to the computer. It recorded weight, body fat, body water, muscle mass, physique rating, daily caloric intake (DCI) and basal metabolic rate (BMR), metabolic age, bone mass and visceral fat rating, gives general physical classification.

The physical activity was recorded with the watch Monitor Garmin Forerunner 610. The data was stored on the watch, later on transferred to the computer by using the Garmin Connect. It recorded data of passed distance, time spent in the activities, GPS position, geographic profiles, pace, heart rate (HR), calories consumed, weight, body fat and body water. Additionally, the heart rate belt was put on workers chest.

2.4. Life Quality Questionnaire (SF-36)

The Life Quality Questionnaire (LQQ) SF-36 based on the Brazilian version (Ciconelli et al. 1999) of the Medical Outcomes Study 36 – Item Short-Form Health Survey (Ware et al. 1994) was answered by 5 sugarcane workers in order to evaluate the impact of work on their life quality. The questionnaire SF-36 has eight scaled scores; the scores are weighted sums of the questions in each section. Scores range from 0 to 100 (where the lower scores represent more disability, and higher scores less disability. The sections are: 1) Physical role functioning; 2) Physical functioning; 3) Bodily pain; 4) General health perceptions; 5) Vitality; 6) Social role functioning; 7) Emotional role functioning; 8) Mental health.

2.5. Experimental protocol

Before the experiment was conducted, the research team met the workers at 05:30 am in the enterprise ambulatory, explaining the comprehensive detail and purposes of the study and possible risks of the participation, with explanation on the purpose, benefits, equipment which will be used. Afterward the informed consent was read and signed.

The body composition measurements were conducted at 06:00, 11:20 and 16:00 hs during both measuring days.

Once arrived to the sugarcane plantation, the watch and HR belt was put on workers, measuring physical activity throughout the working day.

A codification was used for all workers (W1; W2; W3; W4 and W5), where the workers W1 and W2 conducted activity type 1 and workers W3 and W4 activity type 2. The worker W5 participated only in answering the LQQ.

2.6. Clothing

The personal protective equipment used by the subjects were: leather boot with metal toe cap, cotton gloves, reflective waistcoat and sun hat covering the back side of the neck.

2.7. Data analysis

The references were searched through databases by using the institutional IP address of the University of Pernambuco federate credentials. References were managed using the Mendeley 1.15.3. The body composition and physical activity were captured and processed using Tanita's Healthy Edge Software. Statistical analysis were done by using excel statistical toolbox.

3. RESULTS

As noticed during the experimental days, the working regime was different than officially prescribed.

For the working activity 1, it was noticed that the morning working periods were ≈3:35hs, with resting periods of ≈2:35hs. Afterward, they had a lunch break of ≈1:50hs. The afternoon working periods were ≈2:30hs, with resting periods of ≈1:30hs. In total, the working activity 1 had a working period of ≈6:05hs and resting period of 5:55hs.

For the working activity 2, it was noticed that the morning working periods were ≈4:10hs, with resting periods of ≈2:00hs. Afterward, they had a lunch break of ≈1:50hs. The afternoon working periods were ≈2:28hs, with resting periods of ≈1:32hs. In total, the working activity 2 had a working period of ≈6:38hs and resting period of 5:22hs.

The results from the Life Quality Questionnaire are illustrated in the Table 3. The answers which had scores of less than 50 were grey-shaded.

Table 3. Results from the Life Quality Questionnaire

	Question	W1 (%)	W2 (%)	W3 (%)	W4 (%)	W5 (%)	Average (%)	Standard deviation (%)
1	Physical role functioning	90	90	95	95	95	93	±2.74
2	Physical functioning	75	75	75	75	75	75	±0
3	Bodily pain	100	52	62	62	62	67.6	±18.6
4	General health perceptions	52	52	55	55	47	52.2	±3.27
5	Vitality	60	45	50	45	55	51	±6.52
6	Social role functioning	87.5	87.5	87.5	87.5	87.5	87.5	±0
7	Emotional role functioning	100	100	100	100	100	100	±0
8	Mental health	48	48	52	52	52	50.4	±2.19

The most important results from the body composition measurements and measured physical activity were illustrated in the Table 4.

Table 4. Main data gathered from daily working activities

	W1 activity 1	W2 activity 1	W3 activity 2	W4 activity 2
Body Mass Index (BMI)	27.0 26.9 25.9	24.6 24.9 25.1	20.4 21.3 21.0	30.0 30.2 28.6
Body Water (%)	55.2 56.2 57.8	57.8 59.7 59.4	57.8 57.8 58.3	51.9 58.9 53.2
Passed distance (km)	5.3	3.8	12.39	10.25
Time measured	7h 50' 24''	6h 53' 41''	8h 38' 24''	8h 24' 19''
Calories (kcal)	2118	979	2319	2614
Metabolic heat production (kcal/h)*	270	140	269	311
Average HR (bpm)	98	90	118	118
Max HR (bpm)	128	131	161	180

4. DISCUSSION

4.1. Life Quality Questionnaire

It was observed that there are no repetitive movements of the same muscular group during the execution of the tasks for working activities 1 and 2. The working tasks were only repeated for short intervals ≈30 seconds, and it didn't exceed more than 50% of the working day. In comparison, one study concluded that sugarcane cutters conducted repetitive movement with their trunk (Messias and Okuno 2012). Additionally, a number of unfavourable body postures were found for the working activity 2. The upper limbs and spine were more affected while conducting the working tasks, while for specific tasks - specific muscle groups had a higher strength requirement.

The life quality questionnaire shows workers perception on how their work influenced their health status during the past 4 weeks. High scores (meaning no or low influence) were given on physical role functioning, physical functioning, bodily pain, social role functioning and emotional role functioning.

As they answered to be feeling exhausted a small part of the time, feeling fatigued part of the time, and feeling nervous a great part of the time, low scores (meaning more disability) were given on general health perception, vitality and mental health respectively. All workers which participated in the study responded to feel discouraged or depressed sometimes, even though feeling happy most of the time. Therefore, the results show that all evaluated workers experienced mood alterations during the past 4 weeks. Anxiety might be a reason for the encountered lower scores, as it was found that all analyzed workers were not in a good fitness condition (Wasley et al. 2012). The fitness condition was measured during a three-stage cycle test, expressed as estimated VO2max, derived from the individual steadystate HR rate response.

4.2. Heat stress risk

There are six basic factors to consider for determining the human thermal environment: air temperature, radiant temperature, relative humidity, air movement, metabolic heat production and clothing worn by the person. The outside air temperature varied from 17.9°C (at 06:00 hs) to 30.2°C (at 17:00 hs).

The metabolic rate was calculated according to the ISO standard (ISO 8996 2004), resulting in 270, 140, 269, and 311 kcal/h for workersW1, W2, W3 and W4 respectively. The calculated metabolic heat production show a moderate working activity according to the ISO standard (ISO 8996 2004) and the Brazilian legislation (Brasil 1978) for workersW1 and W3, a light working activity for the workerW2 and a slightly above moderate for the workersW4 (recorded 311 kcal/h, while a threshold for moderate is till 310 kcal/h, and above 310 kcal/h till 400 kcal/h is categorized as high metabolic rate according to ISO 8996). A high metabolic rate in the workerW4 might be also influenced by his high BMI. Individuals with high BMI have significantly higher body fat, which means lower heat capacity, with reduced capability to dissipate excessive body heat (Selkirk et al. 2001), leading to higher core temperature and therefore posing higher heat stress risk. Nevertheless, this comparison has its limitation, as the number of workers participating in the study was low, and as the metabolic rate was calculated according to the working hours of each of the workers, which varied from 6hs 53min to 8hs 38min, while the ISO

standard give the classify the values for the 8 hours working period.

Considering the Brazilian legislation, work/rest regimes should be applied for the light working activity (W2) when air temperatures exceed 30.0°C, and for moderate working activity (W1, W3 and W4) with air temperatures higher than 26.7°C. In comparison with this study, another study found higher values and variations while evaluating metabolic heat production among sugarcane workers (Crowe et al. 2010). The highest mean values for 25 sugarcane cutters was 425.63 kcal/h (varying among workers from 171.9 to 450.5 kcal/h), and from 13 sugarcane workers applying dry fertilizers it was 397.3 kcal/h (from 164.1 to 406.3 kcal/h). The results from that study (Crowe et al. 2010) might be influenced, as the evaluated groups were formed with managers and other different working positions which might have had much higher or lower metabolic heat production.

Nevertheless, while in that study evaluated working positions show mean values with high metabolic heat production, in our study working metabolic heat production was mostly moderate (from 140 to 311 kcal/h).

Further on, although not considered by the Brazilian legislation, it is important to notice that the relative humidity decreased and air movement increased from morning till evening. Therefore, although the air temperature was higher during the afternoon, reduced relative humidity and increased air movement facilitated the sweat evaporation and contributing by removing excessive thermal energy from the body (Havenith 2005; Saladin and Miller 1998).

Therefore, all the measured workers, during the evaluated days, could work continuously during the morning period (when it was noticed that most of the work was conducted), but had to consider work/rest periods during the afternoon. As it was noticed, the working activities were self paced, meaning that workers would rest or reduce their working rate when they would feel fatigued. Further on, the working activities were found to be cyclical, and that workers from working activity 1 and 2 would rest after the truck was loaded, waiting for the truck to return empty.

4.3. Hydration status and fitness condition

The weighting scale measurements on hydration status don't show any signs on dehydration among the measured workers. Although workers were found to be well hydrated, the measured percentages of body water show that they were not in a good physical shape. Muscles contain more water than fat; therefore athletes have high percentage of body water. The workers had body water from 51.9 and 59.7%, which is in between the value for an old person (≈50%) and an average person (≈60%). Therefore it could be concluded that those workers were not in a good fitness condition (K.C.Parsons 2003).

4.4. Heart rate

The measurements from this study found that mean HR levels ranged from 90 to 118 beats/min, while HRmax levels ranged from 128 to 180 beats/min. Important to notice is that the HR was found to be lower for the activity 1 (HRmax for W1 and W2 lower than 131 bpm) in comparison with the activity 2 (HRmax for W3 was 161 bpm, while for W4 was 180 bpm). Although HR variations follow a similar pattern in workers conducting the working activity two, the HRmax in W4 was found to be higher than in W3. As the working activity was similar, the explanation could be found in the body mass index which was very high (≈30) of W4, being considered as obese, in comparison with ≈21 of W3, being considered as healthy. Therefore, although the W4 is young (23 years old), with his high BMI value, and if there would be prolonged HR levels of ≥138 bpm, there would be a risk of heat disorders (Tian et al. 2011). Another study conducted on 6 sugarcane workers, but considering sugarcane cutters recorded that they were working ≈42 min (≈5.7 hours in total during the day) and resting ≈18 min during each working hour, with a mean HR of 133bmp (from 119 to 143 bpm) and HRmax of 185 bmp (from 168 to 200 bpm) (Reis 2014). Therefore, the sugarcane cutters conduct a heavier work than workers conducting the activity 1 from this experiment, and heavier than workers conducting the activity 2.

4.5. Future studies

Future studies should include more participants conducting different outdoor working activities (road repair, marine, army, agriculture, forestry, construction work and related occupations). Further on, apart from the measuring techniques included in this study, it would be interesting to measure the core body temperature in order to fully evaluate the workers heat stress risk

during the whole working day. Future studies should consider the experience gathered from this experiment and consider measuring weight with and without clothes before and after the working activity. By that, it would be possible to evaluate the amount of sweat which participated in the body cooling process and the amount of sweat trapped inside the clothes. The amount of water consumption could be easily measured in order to have more data and therefore comprehend better how to remain well hydrated when exposed to high environmental temperatures.

5. CONCLUSIONS

The evaluated working activities show moderate metabolic heat production, work done on self pacing, with resting periods due to the working process, which was found to be appropriated to the thermal environment conditions to which the workers were exposed. However, as thermal conditions change, work/rest periods should be re-evaluated and if needed, adapted in order to minimize heat stress risk among workers. Further on, it would be to consider fitness condition among workers as high level of aerobic fitness were found to tolerate higher core temperatures, lower body mass index contribute to higher dissipation of excessive body heat, and therefore contribute to reduce heat stress risk. The workers were found to be well hydrated. The two evaluated sugarcane working activities (Portuguese “Bituqueiro” and “Atrelhador”) were found to have a lower metabolic heat production compared to sugarcane cutters.

REFERENCES

Alves, Francisco. 2006. “Por Que Morrem Os Cortadores de Cana?” *Saude e Sociedade* 15(3):90–98.

Brasil. 1978. *NR 15 - Atividades E Operações Insalubres*. Vol. 04. edited by B. Ministério do Trabalho e Emprego.

Canadian Centre for Occupational Health & Safety. 2016. “Hot Environments - Health Effects and First Aid.” Retrieved January 13, 2017 (https://www.ccohs.ca/oshanswers/phys_agents/heat_health.html).

Carlowicz, Michael. n.d. “Global Temperatures.” *NASA Earth Observatory*. Retrieved January 13, 2017 (http://earthobservatory.nasa.gov/Features/WorldOfChange/decadaltemp.php).

Ciconelli, R. M., M. B. Ferraz, W. Santos, I. Meinão, and M. R. Quaresma. 1999. “Tradução Para a Língua Portuguesa e Validação Do Questionário Genérico de Avaliação de Qualidade de Vida SF-36 (Brasil SF-36).” *Revista Brasileira De Reumatologia* 39:143–50.

Crowe, Jennifer, José Manuel Moya-Bonilla, Bryan Román-Solano, and Andrés Robles-Ramírez. 2010. “Heat Exposure in Sugarcane Workers in Costa Rica during the Non-Harvest Season.” *Global Health Action* 3:1–9.

García-Trabanino, Ramón, Emmanuel Jarquín, Catharina Wesseling, Richard J. Johnson, Marvin González-Quiroz, Ilana Weiss, Jason Glaser, Juan José Vindell, Leo Stockfelt, Carlos Roncal, Tamara Harra, and Lars Barregard. 2015. “Heat Stress, Dehydration, and Kidney Function in Sugarcane Cutters in El Salvador - A Cross-Shift Study of Workers at Risk of Mesoamerican Nephropathy.” *Environmental Research* 142:746–55.

Havenith, George. 2005. “Temperature Regulation, Heat Balance and Climatic Stress.” *Extreme Weather Events and Public Health Responses* 69–80.

ISO 8996. 2004. “Ergonomics – Determination of Metabolic Heat Production.” *International Standards Organisation*.

Jacklitsch, B., WJ Williams, K. Musolin, A. Coca, J. H. Kim, and N. Turner. 2016. “NIOSH Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments.” *US Department of Health and Human Services* Publication 2016-106.

K.C.Parsons. 2003. *Human Thermal Environments: The Effects of Hot, Moderate, and Cold Environments on Human Health, Comfort and Performance*. Second edi. Taylor & Francis.

Messias, Iracimara de Anchieta and Emico Okuno. 2012. “Study of Postures in Sugarcane Cutters in The.” *Work* 41:5389–91.

NETAFIM. n.d. “Clima.” Retrieved January 13, 2017 (http://www.sugarcanecrops.com/p/climate/).

ONG Repórter Brasil. n.d. “As Condições de Trabalho No Setor Sucroalcooleiro.” Retrieved January 13, 2017 (http://trabalhonacana.escravonempensar.org.br/condicoes-de-trabalho-nos-canaviais/).

Reis, Felipe Rovere Diniz. 2014. “Avaliação e Controle de Risco de Estresse Térmica Dos Trabalhadores No Corte Manual de Cana-de- Açúcar.” *Revista Brasileira de Medicina Do Trabalho* 12(2):73–78.

Saladin, KS and L. Miller. 1998. *Anatomy & Physiology*. OpenStax College.

Selkirk, Glen A., Tom M. Mclellan, Jill M. Stapleton, Martin P. Poirier, Andreas D. Flouris, Pierre Boulay, Ronald J. Sigal, Glen P. Kenny, Ollie Jay, Anthony R. Bain, Tomasz M. Deren, Matthew Sacheli, Matthew N. Cramer, Elizabeth G. Hanna, Tord Kjellstrom, Charmian Bennett, and Keith Dear. 2001. “Influence of Aerobic Fitness

and Body Fatness on Tolerance to Uncompensable Heat Stress." *Journal of Applied Physiology (Bethesda, Md.: 1985)* 91:2055–63.

Souza, C. D. R., A. B. G. J. Filho, and R. A. V. Silva. 2012. "Impacts of Introducing a New Tool for the Manual Harvesting of Sugar Cane: The Ergonomic Analysis Contribution." *Work* 41:4967–70.

Tian, Zhe, Neng Zhu, Guozhong Zheng, and Huijiao Wei. 2011. "Experimental Study on Physiological and Psychological Effects of Heat Acclimatization in Extreme Hot Environments." *Building and Environment* 46(10):2033–41.

Tribuzi, G. and J. B. Laurindo. 2016. "Dehydration and Rehydration of Cooked Mussels." *International Journal of Food Engineering* 12(2):173–80.

Ware, J. E., K. K. Snow, M. Kosinski, B. Gandek, and Sherbourne. 1994. "Medical Outcomes Study Questionnaire Short Form 36 Health Survey (SF-36)." *Med Care* 32(306).

Wasley, David, Adrian Taylor, Karianne Backx, and Aaron Williamon. 2012. "Influence of Fitness and Physical Activity on Cardiovascular Reactivity to Musical Performance." *Work* 41:27–32.

Wesseling, Catharina, Aurora Aragón, Marvin González, Ilana Weiss, Jason Glaser, Norma A. Bobadilla, Carlos Roncal-Jiménez, Ricardo Correa-Rotter, Richard J. Johnson, and Lars Barregard. 2016. "Kidney Function in Sugarcane Cutters in Nicaragua - A Longitudinal Study of Workers at Risk of Mesoamerican Nephropathy." *Environmental Research* 147(April):125–32.