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Research Article

Block Laying Heights and Physiological Indices in Masonry Work

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Abstract

This study investigated the physiological response functions of the masons during masonry work using three standard sizes of construction block weights at varying working heights. The assessment involved a repeated job handling design approach. The participants in this study were 12 masons who had at least one year of experience in working with sandcrete blocks and burnt bricks. Each participant constructed 20-block walls, 7 courses high using 9 inches and 6 inches sandcrete blocks and 20-block wall, 11 courses high using burnt bricks. The physiological response data measured were heart rate, body temperature and blood pressures (systolic and diastolic) at each wall height constructed. The ergonomic investigation principle of the work factors affecting masonry work was hinged on known physiological indices (oxygen consumption and energy expenditure rate) to evaluate the degree of the effects of the task on masons. The result obtained showed that the masons experienced different levels of stresses at ground level to knee height, knee height to chest height and neck height while working with the 6 and 9 inches sandcrete blocks. The building construction using burnt bricks recorded varied results, as there were no differences in body temperature, heart rate and blood pressure throughout the wall height. This study concluded that the construction block weights have effect on the physiological response functions of the masons at varying working heights.

Keywords

Mason, Blocks, Burnt bricks, Working height, Load mass, Physiological response

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1. INTRODUCTION

Masonry is the building of structures from individual material units laid in and bound together by mortar. A bricklaying job operation is a repeated work operation ordinarily carried out on-site by masons. The use of masonry construction materials such as brick, stone, marble, limestone, granite, travertine, concrete block, cast stone, stucco, glass block, and tile in the erecting of building structures is referred to as masonry construction work. In the construction industry, erecting and dismantling scaffolding, handling blocks/bricks and mortar, laying blocks/bricks, and grouting are all physically demanding jobs with a significant risk of work-related accidents [1-4]. In addition to being physically demanding, tasks undertaken by masons can vary throughout the day, requiring repetitive, awkward, and static postures in potentially harsh outdoor environments. In handling the building materials, either bricks or blocks, Van der Molen *et al.* [5] found that the most demanding task of masons was a one-handed repetitive lifting of bricks and two-handed lifting of blocks. These activities require a mason to bend, lift and twist in laying a brick/block. Sometimes, works are done at heights above the worker's shoulder level. Studies emphasized that construction materials handling is more often than once every five minutes. Working height an individual's shoulder level is the most significant contributing factor in neck/shoulder trouble and neck/shoulder pain [6].

Masons commonly lay 200 or more Concrete Masonry Unit (CMU) blocks each day in brick masonry work [7, 8]. Anton *et al*. [9] stated the load specific of CMU block as weighing 16.3 kg and 0.2m × 0.2m × 0.4m dimensions. In an 8-hour shift, a mason handling 200 CMU blocks weighing 16.3 kg each will lift nearly 3260 kg (3.3 tons). The average number of bricks laid by a mason in a day is 1000, according to Schneider and Susi [10]. Laying this number of bricks/block per day in the work variable condition such as load mass and working heights can cause a significant physical load and consequently musculoskeletal disorders (MSD) for masons. Bureau of Labor Statistics (BLS) [11] recognized masonry construction as one of the high-risk speciality trades with the nonfatal incident rate of 191.5 per 10,000 equivalent full-time workers and 2,640 recordable injuries. In other construction trades working with hands above shoulder level leads to reports of shoulder discomfort [12]. Schneider and Susi [10] found that masonry had the second-highest incidence rate of accidents with lost workdays due to overexertion involving bending, lifting, and twisting. They further reported that the associated cost of medical care of masons was the highest of all construction occupations [4, 10]. The block weight lift height for the block and mortar, the placement height for the block, buttering (mortar application and smoothing) activities, and the work distance from the mason are all risk factors for back and shoulder injuries associated with handling block [3, 13, 14].

In a lab setting investigated by Anton et al. [9] on masons, surface electromyography of some upper extremity (forearm flexors and extensors) and back (erector spinae) muscles were lower when using a light-weight block (weighing 11.8 kg) compared to the standard medium weight block (16.3 kg). To adopt another alternative masonry material, Autoclaved Aerated Concrete (AAC) with a mass range of 15.7 kg to 25.7 kg in place of CMU with a mass range of 11.8 kg to 29.5 kg, depending on block size, aggregate composition, and moisture exposure, it was discovered that because AAC is one-third longer than CMU, masons can build more walls with each block laid because it is larger. However, the size makes it more awkward to handle, thus the potential for MSD risk reduction in terms of its lighter weight is not known. Brouwer et al. [15] examined the effect of lowering the mass and reducing the size of gypsum bricks in a laboratory setting. The weight of the bricks was reduced by 30% through the reduction of the dimensions by 50% and hollowed. The study found that reducing the load mass reduced the biomechanical load on the spine and the physiological cost by lowering the heart rate with a significant increase in the efficiency and construction time [15, 14]. Other approaches recommended for the reduction of the physical workload of bricklayers include technical changes to improve scaffolding systems, provision of raised platforms and tables for placing materials, and reduction of block weights to less than 4 kg and restriction of their maximum width to 105 mm [16]. Other studies focused on engineering controls like the lightweight blocks use for the reduction of the masonry workers' ergonomic demands [4, 8-9].

According to Ciriello *et al*. [17], many basic ergonomic principles are ignored, thereby costing as much as 31% of the insurance costs paid by the insurance companies due to manual material handling in the construction, trucking and service industries. When a worker is exposed to physical stress either from the job design or the process strategies, there is a corresponding strain manifested in the physiological responses of the worker. These include the heart rate, blood pressure, respiratory rate, oxygen consumption and stroke (pulse volume). The most commonly used measures, however, are our heart rate and energy consumption. Although heart rate is a good indicator of stress, it is also affected by mental stress and other personal aspects such as constitution, physical condition, and sex. Thus, this study investigated an absolute index of load on physical work measurement using oxygen consumption in the identification of the physiological response functions of the masons during masonry work when different construction block weights are handled at varying heights.

2. MATERIALS AND METHODS

This research was carried out in Makurdi, Benue State. The Benue trough is located in Nigeria's middle belt, between latitudes 6°25′ and 8°8′ North, and longitudes 7°47′ and 10°0′ East. Benue state's terrain is primarily undulating plains with occasional elevations of 1,500 to 3,000 meters above sea level. The state has a total land mass of 34,059 km² and shares boundary with six states of the federation; Nasarawa to the North, Cross river to the South, Taraba to the East, and Kogi to the West, Enugu to the South-west and an additional Nord-Quest province to the South-east (Fig. 1) [18]. From the meteorological condition of the study area presented by a study is stated to have ambient temperature of 23℃ to 30℃ at maximum temperature of 38℃ [18]. The range of the rainfall presented on yearly basis ranges from 900 mm to 1200 mm [19].

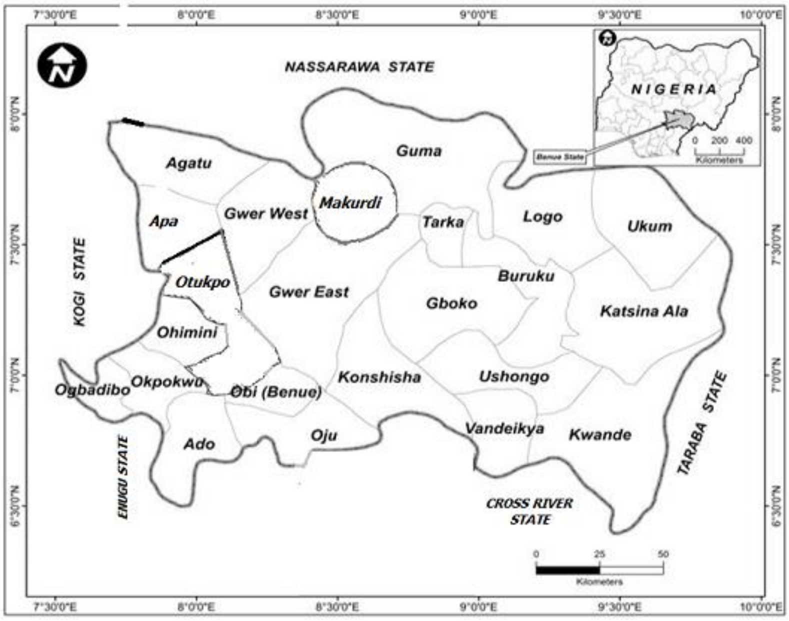

Figure 1. Map of Benue state (the study area) [18].

The research methodology involved the use of twelve (12) bricklayers as subjects. The participants had at least one year of experience in working with sandcrete blocks and burn bricks similar to those used in this study. The anthropometry variables of the workers assessed were the knee, waist and neck heights. From October to November 2012, the assessment the block laying was conducted in the outside environment between the hours of 8 a.m. and 5 p.m. The working variables assessed was the working heights in the repeated job operation of handling varying blocks and brick in masonry construction. Blocks and bricks referred to as building blocks for the purpose of discussion in this work were typically considered in this research work as they are produced in common or standard sizes in bulk quantities. The masses of the three building blocks; burnt bricks (12x10x24 cm), 6 inches hollow blocks (15.5x23x46 cm) and 9 inches hollow blocks (23x23x46 cm) used for the study were 3.934 kg, 15.280 kg and 19.560 kg respectively (see Fig. 2).

3.934kg 15.280kg 19.560kg

Figure 2. Building blocks used in the study

The regular brick laying operation in the building of structures was followed through repeated actions of mortar application, building block lifting, laying and setting, and buttering activities. The building blocks were stacked to five layers of 6 and 9 inches sandcrete blocks from the ground which gave an elevation of 110 cm height at the top of the fifth layer. For the burnt bricks, it was 10 layers and the top of the tenth layer was at 96cm. The stacked building blocks arrangements were five metres away from the construction portion. The constructed wall was made up of 20 blocks (920cm) in length and up to 7 blocks (138 cm) in height for 6 inches and 9 inches and 20 blocks (480 cm) in length and up to 11 blocks (110 cm) in height for burn bricks. The principle used in the ergonomic investigation of the work factors affecting masonry work was hinged on known physiological indices to evaluate the degree of the effects of the task on masons.

(a) (b) (c)

Figure 3. Research instrumentation: (a) a 50m flexible ruler, (b) digital clinical thermometer, (c) a digital sphygmomanometer

The measurements which formed the basis for evaluation include: the body temperature of the workers, their heart rates and systolic and diastolic blood pressures. The building blocks were stacked the way they are normally stacked in the construction industry. The following tools were used in this research work for data collection: A 50m flexible ruler made of a fibre material (model TU1450) (Fig. 3a) with a measuring range of 0 – 50 m was used to measure the working heights. A digital clinical thermometer with accuracy of 0.1 ºC and measurement range of between 34.0 and 42.0 °C was used for the workers body temperature (Fig. 3b). The workers' systolic and diastolic blood pressures were measured with a digital sphygmomanometer (model MCBP) with an accuracy of 3 mmHg. As well it was used to measure the workers' number of heart beats per minute (Fig. 3c). The sample data computation was done using Statistical Package for the Social Sciences (SPSS) version 20.0 and the Microsoft Office Excel version 2010 software.

Oxygen Consumption (VO_2) and Energy Expenditure Rate (EER) Estimation:

The participants' oxygen consumption (VO_2) was determined using the heart rate values obtained during the working period by applying [20] expression stated as:

$$Y = 0.259X - 6.422 \tag{1}$$

Where, Y = predicted oxygen consumption in l/min, X = measured heart rate in beats/min

The energy expenditure rate of the workers in physical demanding tasks developed by Saha [21] using the measured heart rate during the work process stated below was used:

$$EER = \frac{HR - 66.0}{2.4} \tag{2}$$

Where, EER = energy expenditure rate and HR = heart rate.

The established grading for work-based scaling of physical loads from the physiological responses of the worker as a factor of the job design or the process strategies of the masons during masonry work when different construction block weights are handled at varying height used is found in Table 1.

Table 1. Grading of work based on scaling of physical loads

Grade of work	Oxygen Consumption l/min)	Energy Expenditure rate (kJ/min)	Heart Rate (beats/min)	Body Temperature (°C)
Very light	<0.5	<10	<75	<37.5
Light	0.5-1.0	10-20	75-100	37.5
Moderately heavy	1.0-1.5	20-30	100-125	37.5-38
Heavy	1.5-2.0	30-40	125-150	38-38.5
Very heavy	2.0-2.5	40-50	150-175	38.5-39.5
Unduly heavy	>2.5	>50	>175	>39.5

3. RESULTS AND DISCUSSION

The descriptive statistics of the age and height of the 12 masons that participated in the masonry work assessed in this study were 33.50 ± 4.74 years and 1.73 ± 0.05 m, respectively.

At each of the 7 block laying courses for the block laying process work process considered using six (6) and nine (9) inches (") blocks, the physiological indices such as body temperature, heart rate, systolic and diastolic blood pressures were obtained from the twelve (12) participants. The average values of the physiological indices at each of the levels were statistically analysed and presented as maximum, minimum, mean, standard deviation and standard error of mean (Tables 2-5).

Table 2. Temperature (°C) mean values for load capacity for manual sandcrete block task at layers 0-7 (6 and 9 inches sandcrete block)

S/N	**Working heights(cm)**	**Maximum**		**Minimum**		**Mean**		**Standard deviation**		**Standard mean error**	
		6''	**9''**	**6''**	**9''**	**6''**	**9''**	**6''**	**9''**	**6''**	**9''**
1	0.0	36.4	36.8	36.0	36.2	36.2	36.5	0.14	0.24	0.04	0.07
2	23.0	36.5	36.8	36.0	36.2	36.3	36.6	0.17	0.21	0.05	0.06
3	46.0	36.8	37.0	36.0	36.4	36.4	36.7	0.29	0.24	0.08	0.07
4	69.0	37.1	37.3	36.0	36.2	36.5	36.8	0.42	0.34	0.12	0.10
5	92.0	37.2	37.2	36.1	36.2	36.6	36.9	0.31	0.32	0.09	0.09
6	115.0	37.8	37.6	36.1	36.4	36.7	37.0	0.60	0.40	0.17	0.12
7	138.0	37.5	37.7	36.2	36.2	36.8	37.1	0.46	0.52	0.13	0.15

Table 3. Heart rate (beats/min) mean values for load capacity for manual sandcrete block task at layers 0-7 (6 and 9 inches sandcrete block)

S/N	Working heights(cm)	**Maximum**		**Minimum**		**Mean**		**Standard deviation**		**Standard mean error**	
		6''	**9''**	**6''**	**9''**	**6''**	**9''**	**6''**	**9''**	**6''**	**9''**
1	0.0	88	94	77	84	82.00	89.92	4.00	3.37	1.15	0.97
2	23.0	96	106	83	88	90.00	100.00	3.49	5.48	1.01	1.58
3	46.0	108	117	89	96	97.83	108.92	5.37	6.92	1.55	2.00
4	69.0	117	132	98	108	106.08	118.08	7.10	6.52	2.05	1.88
5	92.0	130	142	101	110	116.08	124.92	9.82	11.33	2.84	3.27
6	115.0	141	153	111	116	126.92	135.08	9.25	14.34	2.67	4.14
7	138.0	155	161	120	130	136.08	145.92	11.71	10.02	3.38	2.89

Table 4. Systolic blood pressure (mmHg) mean values for load capacity for manual sandcrete block task at layers 0-7 (6 and 9 inches sandcrete block)

S/N	Working heights(cm)	**Maximum**		**Minimum**		**Mean**		**Standard deviation**		**Standard mean error**	
		6''	**9''**	**6''**	**9''**	**6''**	**9''**	**6''**	**9''**	**6''**	**9''**
1	0.0	134	133	130	128	132.08	130.00	1.16	2.00	0.34	0.58
2	23.0	136	146	132	135	134.17	140.08	1.34	3.55	0.39	1.03
3	46.0	138	149	134	137	136.00	142.92	1.13	4.72	0.33	1.36
4	69.0	140	148	134	140	138.00	145.08	1.95	2.71	0.56	0.78
5	92.0	142	153	137	142	140.00	147.00	1.86	3.79	0.54	1.09
6	115.0	145	158	139	141	142.00	149.92	1.91	5.53	0.55	1.60
7	138.0	134	160	130	143	132.08	153.00	1.16	6.15	0.34	1.78

Table 5. Diastolic blood pressure (mmHg) mean values for load capacity for manual sandcrete block task at layers 0-7 (6 and 9 inches sandcrete block)

S/N	Working heights(cm)	**Maximum**		**Minimum**		**Mean**		**Standard deviation**		**Standard mean error**	
		6"	9"	6"	9"	6"	9"	6"	9"	6"	9"
1	0.0	91	91	89	89	90.00	89.92	0.74	0.79	0.21	0.23
2	23.0	92	93	89	91	90.00	92.00	0.95	0.85	0.28	0.25
3	46.0	91	93	88	91	90.00	92.00	1.04	0.60	0.30	0.17
4	69.0	92	93	88	91	90.00	92.00	1.28	0.95	0.37	0.28
5	92.0	94	93	90	91	91.83	91.92	1.40	0.79	0.41	0.23
6	115.0	94	94	90	91	92.00	92.00	1.54	1.04	0.44	0.30
7	138.0	95	94	91	92	93.17	92.92	1.34	1.00	0.39	0.29

Table 6. Temperature (°C) mean values for load capacity for manual burnt brick task at layers 0-11

S/N	**Working heights (cm)**	**Maximum**	**Minimum**	**Mean**	**Standard deviation**	**Standard error of mean**
1	0.0	36.08	35.91	36.00	0.06	0.02
2	10.0	36.10	35.80	35.95	0.10	0.03
3	19.0	36.10	35.90	36.00	0.06	0.02
4	29.0	36.20	35.90	36.02	0.08	0.02
5	38.0	36.20	35.90	36.03	0.10	0.03
6	48.0	36.20	35.90	36.07	0.12	0.03
7	58.0	36.20	35.90	36.08	0.10	0.03
8	66.0	36.20	36.00	36.09	0.08	0.02
9	76.0	36.20	35.90	36.09	0.10	0.03
10	86.0	36.20	35.90	36.10	0.10	0.03
11	96.0	36.20	36.00	36.11	0.10	0.03

Table 7. Heart rate (beats/min) mean values for load capacity for manual burnt brick task at layers 0-11

S/N	**Working heights (cm)**	**Maximum**	**Minimum**	**Mean**	**Standard deviation**	**Standard mean error**
1	0.0	72.00	69.00	69.83	1.11	0.32
2	10.0	72.00	69.00	70.08	1.00	0.29
3	19.0	72.00	69.00	70.17	1.11	0.32
4	29.0	72.00	69.00	70.33	0.89	0.26
5	38.0	74.00	70.00	71.58	1.24	0.36
6	48.0	74.00	70.00	71.83	1.11	0.32
7	58.0	74.00	70.00	72.00	1.28	0.37
8	66.0	74.00	70.00	72.08	1.31	0.38
9	76.0	74.00	71.00	72.33	0.98	0.28
10	86.0	74.00	70.00	72.42	1.24	0.36
11	96.0	74.00	70.00	72.50	1.38	0.40

The descriptive statistics (maximum, minimum, mean, standard deviation and standard error of mean) of the physiological indices (temperature after (°C), heart rate (beats/min), systolic and diastolic blood pressures (mmHg) of the twelve (12) workers assessed for the construction work at each of the 11 laying courses using burnt brick at the working heights range from 0 to 96 cm are presented in Tables 6-9.

Table 8. Systolic blood pressure (mmHg) mean values for load capacity for manual burnt brick task at layers 0-11.

S/N	Working Heights (cm)	Maximum	Minimum	Mean	Standard deviation	Standard mean error
1	0.0	122.00	119.00	119.92	0.90	0.26
2	10.0	122.00	119.00	120.33	1.07	0.31
3	19.0	123.00	119.00	122.00	1.54	0.44
4	29.0	123.00	120.00	122.08	1.38	0.40
5	38.0	123.00	120.00	122.17	1.03	0.30
6	48.0	129.00	121.00	126.00	2.22	0.64
7	58.0	131.00	120.00	126.08	3.73	1.08
8	66.0	132.00	120.00	126.17	3.49	1.01
9	76.0	131.00	120.00	126.17	4.13	1.19
10	86.0	132.00	120.00	126.33	4.12	1.19
11	96.0	132.00	119.00	126.42	4.54	1.31

Table 9. Diastolic blood pressure (mmHg) mean values for load capacity for manual burnt brick task at layers 0-11.

S/N	Working heights (cm)	Maximum	Minimum	Mean	Standard deviation	Standard mean error
1	0.0	83.00	76.00	79.58	2.50	0.72
2	10.0	84.00	76.00	79.92	2.94	0.85
3	19.0	84.00	76.00	80.00	2.26	0.65
4	29.0	85.00	77.00	80.08	3.29	0.95
5	38.0	84.00	76.00	80.25	2.49	0.72
6	48.0	85.00	79.00	82.50	1.88	0.54
7	58.0	85.00	79.00	82.67	2.06	0.59
8	66.0	85.00	80.00	82.75	1.86	0.54
9	76.0	84.00	81.00	82.83	1.40	0.41
10	86.0	85.00	80.00	82.92	1.68	0.48
11	96.0	85.00	80.00	83.17	1.47	0.42

Tables 10 and 11 show the physiological responses; temperature (°C), heart rate (beats/min), and blood pressure (systolic and diastolic) (mmHg) of the workers based on the load masses (6 and 9 inches sandcrete block and burnt brick) and working heights. The physiological reactions of the worker during the masonry work which involved 6 and 9 inches sandcrete block followed a similar trend of body reaction which differs from burnt brick. Research has shown that the human physiological response is dependent on the state of the body. The direct job analysis factor in the assessment of the effect of working height variables on physiological responses in the repetitive manual capabilities for the masonry assessed shows the influence of working height variables on the human physiological reaction conducted under the three standardized load capacities of building blocks; burnt bricks (12×10×24 cm), 6 inches hollow blocks (15.5×23×46 cm) and 9 inches hollow blocks (23×23×46 cm) (Tables 10 and 11).

Table 10. Mean values of temperature, heart rate and blood pressure for Manual Task 1 (6 and 9 inches sandcrete block).

S/N	Working heights (cm)	Temperature (ºC)		Heart rate (beats/min)		Blood pressure (Systolic/Diastolic) (mmHg)	
		Load capacity		Load capacity		Load capacity	
		6"	9"	6"	9"	6"	9"
1	0.0	36.2	36.5	82	90	130/90	130/90
2	23.0	36.3	36.6	90	100	132/90	140/92
3	46.0	36.4	36.7	98	109	134/90	143/92
4	69.0	36.5	36.8	106	118	136/90	145/92
5	92.0	36.6	36.9	116	125	138/92	147/92
6	115.0	36.7	37.0	127	135	140/92	150/92
7	138.0	36.8	37.1	136	146	142/93	153/92

The effect of working heart on the workers heart rate for the construction work using 9 inches sandcrete block is presented in Fig. 4. The graph showed that progressive increased working height during the masonry work has consequent increased the heart rate of the workers.

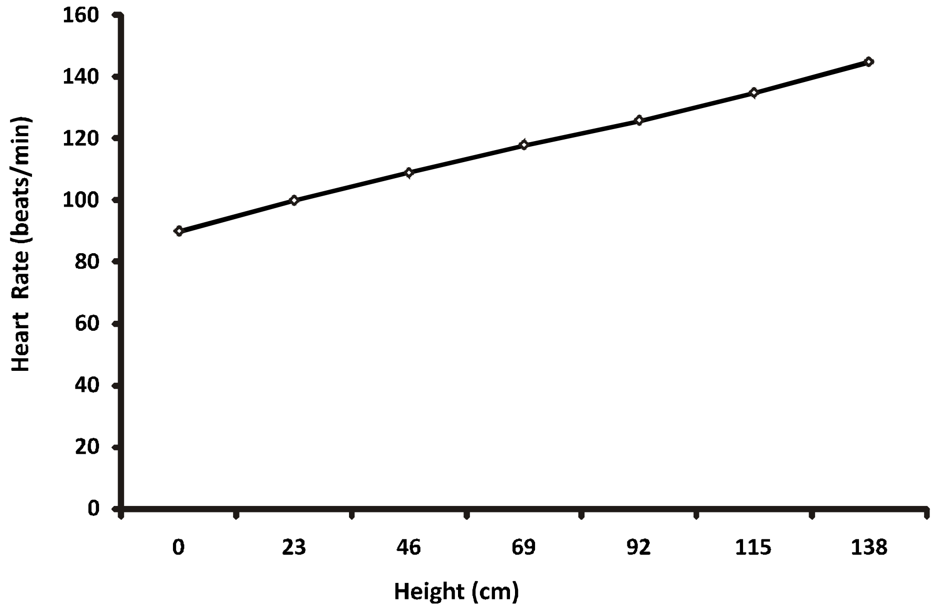

Figure 4. Graph of heart rate versus height

The principle used in the ergonomic investigation of the work factors affecting masonry work was hinged on known physiological indices for the evaluation of the degree of the effects of the task on masons. The oxygen intake by the body represents the respiratory and cardiovascular systems' strength capacity to deliver oxygen and, as a result, release energy to the working muscles. Working conditions can be made to suit workers' functional capacity irrespective of the workers' age, maintenance of the worker's functional capacity is essential [25]. The physiological index of different construction block weights handled at varying heights on physical work measurement using oxygen consumption in the identification of the physiological response functions of the masons during masonry work is the work capacity and stress determining factor. From the ground level to 23.0 cm, the subjects experienced a level of stress, interpreted as light work. At knee height to waist height, i.e. from 46cm – 92cm, the subjects experienced a level of work, interpreted as moderately heavy work. At 92cm to neck height 138cm, the subjects experienced a level of work interpreted as heavy work. This interpretation was based on Saha's [21] and Christensen's [23] criteria presented in Table 1. This result was further translated into energy consumption as follows:

i. From 0 to 23cm height, the subjects consumed 0.5-1.0 l/min of oxygen and between 10-20 kJ/min of energy.

ii. From 46-92cm high the subjects consumed 1.0-1.5 l/min of oxygen and between 20-30 kJ/min of energy.

iii. From 92-136cm high, the subjects consumed 1.5-2.0 l/min of oxygen and 30-40 kJ/min.

According to Lehmann's grading of work as a function of energy expenditure and approximate oxygen intake, the normal task requires 21 kJ/min of energy, with the most optimum being 17.6 kJ/min. The result showed that the energy consumed for the task of constructing a wall at a height of 46-92cm and from 92-136cm lies between 2.4-12.4 kJ/min and 12.4-22.4 kJ/min above that most ideal for a normal task by Saha's [21] and Lehmann's [22] criteria. It can thus be inferred that the energy output for the task of constructing a wall with 9 inches sandcrete block is moderately heavy at 46-92cm and heavy at 92-136cm. The circulatory and respiratory systems' working capacity has been diminished, and as a result, the worker experiences a severe stress on the body's systems as the body tissues body's systems [26].

Blood pressure is the force exerted by the blood as it flows through the walls of the vein. Systolic blood pressure is maximal in the arteries following the contraction of the ventricles usually located on the numerator of the two value presentation format. When the ventricles relax, blood pressure drops to a minimum value that corresponds to ventricular relaxation, which is known as the diastolic pressure and is found in the denominator of the two-value presentation format. The graphical presentation of the effect of working height on the workers' blood pressures for the construction work using 9 inches sandcrete block is presented in Fig. 5.

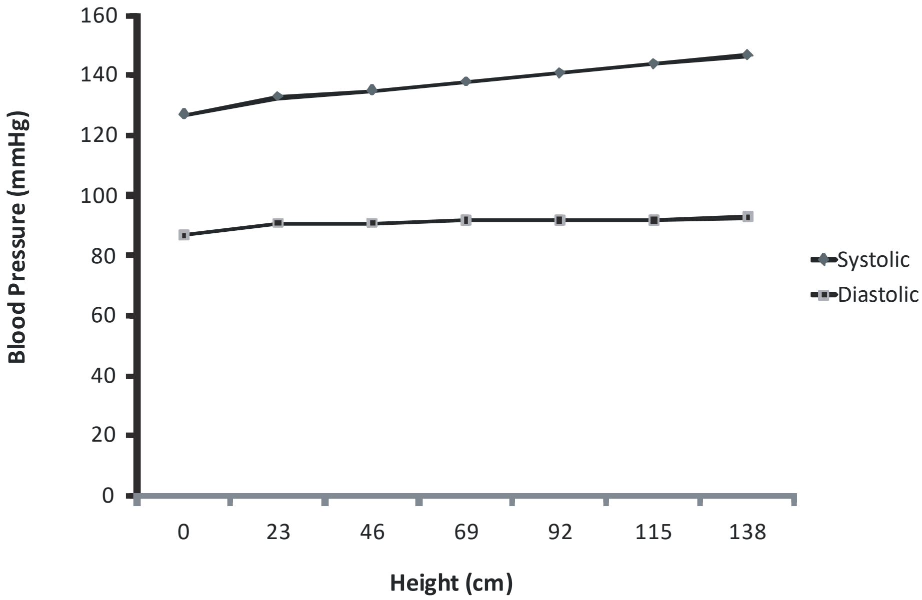

Figure 5. Graph of blood pressures (systolic and diastolic) versus height

For systolic values, there appeared a change throughout the working heights. The diastolic values changed from between the first and second wall height and then remained unchanged till an additional increase of one point in the last stage of work height (115 cm). The analysis presented showed that the subjects were stressed at each stage of the wall height with change in diastolic value after the completion of 23cm wall height. Then between 23cm to 46cm height, the subjects were stressed without changes in diastolic values. From 46cm to 69cm, the subjects were stressed with change in diastolic values and without change till the last working height. If this situation persists for a long time, it will have negative health consequences such as elevated blood pressure, decreased stamina, and, in some cases, damaged lungs.

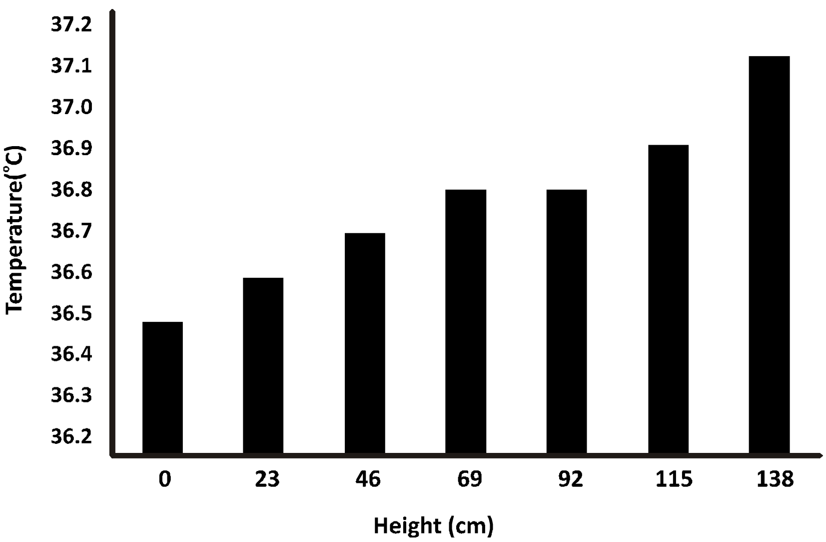

Figure 6. Graph of temperature versus height

The heart rate is defined as the number of heartbeats in one minute. The heartbeat of a normal human being at normal conditions lies between 60-100 beats per minute [27]. However, when rigorous work or emotional stress, the heart rate rises to a higher level, which returns to normal after the exertion is removed. The body temperature of the workers was found to be increasing as the materials were handled at different heights (Fig. 6).

The physiological indices (temperature after (^{o}C), heart rate (beats/min), and blood pressure (mmHg) (systolic and diastolic) of the workers assessed for the construction work using burnt brick at the stated working heights are presented in Tables 11. From the results presented in Table 11 and graphically in Fig. 7, from 0 cm to 96 cm, the subjects experienced a level of stress that resulted in a verdict of very light work. This interpretation was based on Saha's [21], Christensen [23] and Astrand and Rodahl, [24] criteria presented in Table 1.

Table 11. Mean values of temperature, heart rate and blood pressure for Manual Task 1 (burnt brick).

S/N	Brick height (cm)	Temperature (^{o}C)	Heart rate (beats/min)	Blood pressure (Systolic/Diastolic) (mmHg)
1	0	36.0	70	120/80
2	10	36.0	70	120/80
3	19	36.0	70	122/80
4	29	36.0	70	122/80
5	38	36.0	72	122/80
6	48	36.1	72	126/83
7	58	36.1	72	126/83
8	66	36.1	72	126/83
9	76	36.1	72	126/83
10	86	36.1	72	126/83
11	96	36.1	72	126/83

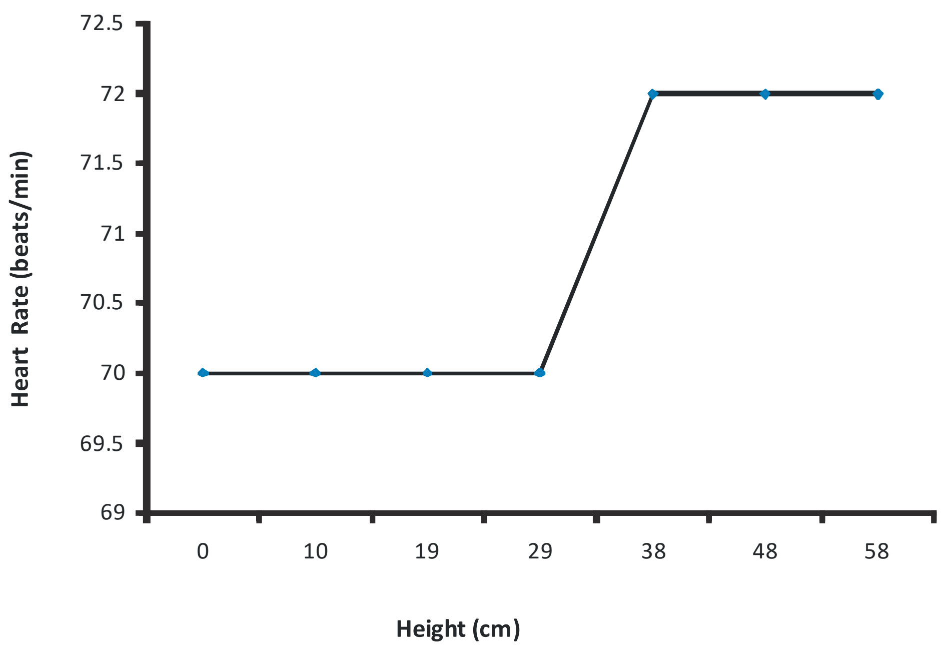

Figure 7. Graph of height versus heart rate.

Throughout the construction of the wall height, oxygen consumption was at less than 0.5 l/min, and energy consumption less than 10 kJ/min. By Lehmann's [22] grading of work, the task of constructing a wall at different heights with this block weight lies below the most ideal energy consumption of 17.6 kJ/min. Thus it can be inferred that the energy output for the task of constructing a wall with this block weight by Saha [21] and Lehmann's [22] criteria makes it light work.

The results in Table 11 and graphically in Fig. 8 indicated that for systolic values, there was no change until 19 cm, then a change that stayed consistent until 48 cm which remained unchanged to 96cm height. For diastolic values, there appeared no change for the first two working heights and then a change that remained constant to 48cm height. In this type of situation presented in Fig. 8, there is apparently no changes in blood pressure for all the wall heights.

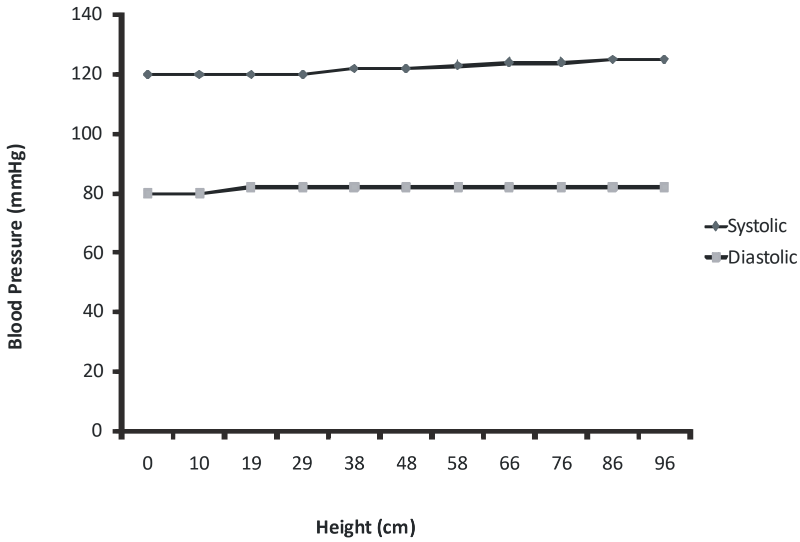

Figure 8. Graph of height versus blood pressure

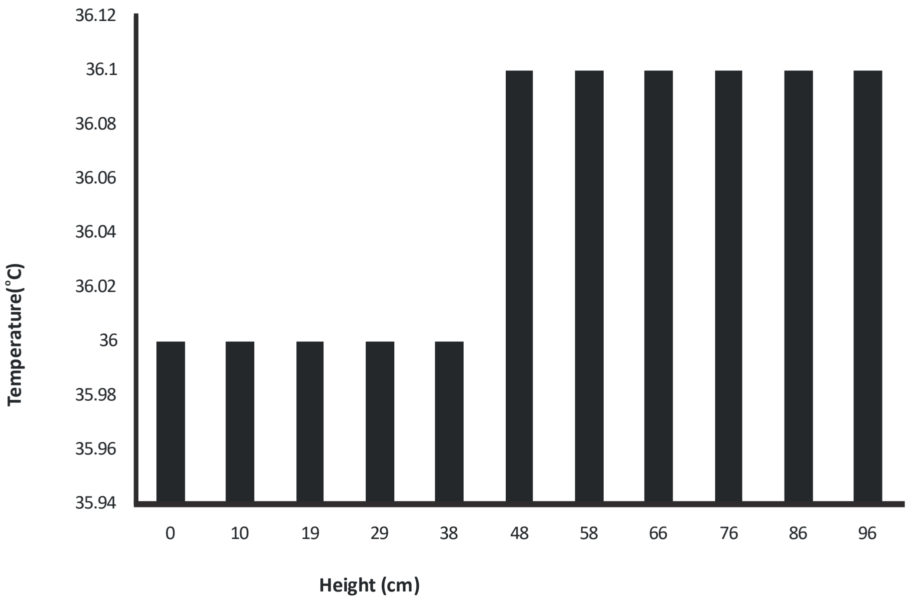

Figure 9. Graph of height versus heart rate

The results of the effect of working height on the temperature of the workers during the masonry work that involved burnt bricks are presented in Fig. 9. The graph indicated that the workers temperatures were not affected until the working height of 48 cm and it remained unchanged from 48 to 96 cm.

4. CONCLUSIONS

In conclusion, it was found from the research that during the construction of the wall using 9 inches sandcrete blocks, masons experienced a level of stress that was light just before knee height and moderately heavy from knee to chest height and heavy from chest to neck height. Masons constructing a wall using 6 inches of sandcrete blocks experienced a level of stress that was light from 0.0cm to kneel height and moderately heavy from above kneel height to chest height, and heavyweight from chest to neck height. Masons constructing a wall using burn bricks experienced a level of stress that was light throughout the wall height. This study recommended adjustable scaffolds should be used to keep working height between 60 to 90 cm. The bricks should be stacked to at least 50cm in height. Engineering controls like the use of lightweight blocks to reduce the ergonomic loads of masonry workers.

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