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Exploring Heat Stress in Indoor Hall for Chess in Nigeria, A Study

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Abstract: ***This research work focuses on the evaluation of occupants' thermal stress during the chess event at the Nigerian University Games (NUGA 2022), with particular emphasis on advancing passive design strategies for indoor sports hall environments. As the push for sustainable building practices gains momentum, this study delves into the application of passive design principles to enhance occupants' thermal comfort without heavy reliance on active cooling methods. The NUGA Games event serves as a pertinent case study; a mixed method of research was used in investigating the extent of thermal stress experienced by individuals within the indoor hall. By analyzing variables such as the thermal sensation votes (TSV) of the occupants by means of questionnaires and interviews, then a qualitative comparison of the games were done using Stockfish® chess engine to detect blunders and inaccuracies, these games quality yields were then exported to analyze if heat stress experienced by the players has a direct relationship with the games quality, Finally, the detailed energy performance evaluation report of the hall was done, using Graphisoft EcoDesigner STAR®. These research instruments highlighted that the heat load was greater when the passive cooling method was used in the hall. They go on to support the idea that everyone's experience with heat stress, had an impact on their ability to perform. Inferences were drawn from these findings, tailoring passive design approaches for general indoor games occurrences and thereby promoting the creation of sustainable and pleasant sporting arenas.***

Key words: active cooling methods, energy performance, passive design, sustainable designs, thermal sensation votes (TSV).

1.Introduction

Buildings are responsible for 40% of global energy consumption and 33% of greenhouse gas emissions (World Economic Forum, 2021). The whole world is tending towards sustainability and architecture should chart the way for low or zero-net energy buildings (Todorović, 2012). Wholistic design should incorporate intelligent, rather than dumb buildings as opined by Salihu,B.(2006) to reduce "gadgetry" as a solution that leaves more carbon footprints on the earth. As the indoor comfort is the salient design requirement, an architect needs to make in any utilitarian space designed, the indoor air quality (IAQ) top priority. Nimlyat,S et al. (2023) have shown that the components of IAQ are the purity, temperature, humidity and wind velocity. Of which thermal comfort comprises of the latter three elements hence it consumes the most energy in making the IAQ okay for the occupants. This implies that mitigating these factors is of the uttermost importance in the design and construction of buildings, in the summer season of temperate regions and in the tropical regions of the world. In hot regions/season, the concentration is mostly on cooling rather than heating the buildings designed. To achieve this passive cooling methods that curb the menace of solar heat gain are rigorously employed in the design of buildings Ajibola, K. (1981), as a matter of fact, Koenigsberger & Lynn, (1965) have asserted that these building types are no more universally accepted. They also argued that modern building materials- "sandcrete" blocks, galvanized iron sheets, asbestos cement, aluminium, burnt brick clay and concrete- which were "originally developed in Europe, are not ideally suited to the climatic conditions of the equatorial regions (tropics)". The two most important part of building in terms of heat gain are the walls and the roofs. Most of these studies are concentrated on the outer shell of the building and have little or no inputs on the occupants. However, researchers like. Rajapaksha,U. (2020); Szokolay,S.(2017): Ayeni, et al., (2018), have reinstated that controlling environmental solar heat gains into buildings due to high levels of ambient air temperature, internal heat generation from occupants and equipment together with enhancing heat escape from indoors determines the thermal balance in buildings.

2.Previous studies

First instrumental work in the area of thermal comfort and occupants' perception was performed by Fanger,O. (1970) where he stated that "the human thermoregulatory system acts to restore heat balance within wide limits of the environmental variables, even if comfort does not exist". The Fanger's model is based upon an energy analysis that takes into account all the modes of energy loss (L) from the body, including: the convection and radiant heat loss from the outer surface of the clothing, the heat loss by water vapor diffusion through the skin, the heat loss by evaporation of sweat from the skin. He was able to get ways of determining the predicted mean votes (PMV) and the predicted percentage of dissatisfied (PPD) of the occupants, creating the rejection index for this postulation. Other researchers that have worked further on more comprehensible thermal sensation variables like Priyam,T & Rana,V (2021), showed that the human body as presented in Fig.1, transfers heat to the surrounding through the following processes:

- Convection (air currents over the body, creating a cooling effect by inducing some evaporation over the skin),
- Conduction (contact heat transfer with other surfaces, e.g., flooring, furniture)
- Radiation (instantaneous infrared heat transfer with any visible object or surface at a different temperature than a person's body, e.g., the sun, the floor, the walls of a room)
- Person's biological processes including evaporation (e.g., sweating, exhalation).

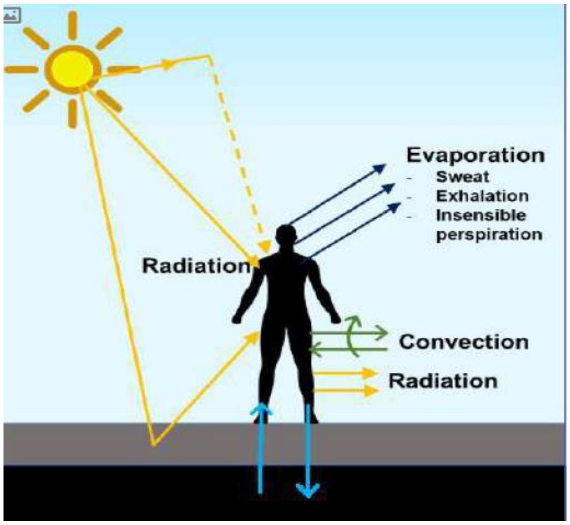


Figure 1: Heat exchange for human thermal comfort
Source: Priyam & Rana. (2021).

According to ASHRAE Handbook : Heating, Ventilating, and Air-Conditioning Applications (2015) , there are six primary factors shown in Fig 2, that directly affect human thermal comfort and are generally grouped in two categories:

- Personal factors: characteristics of the occupants (including clothing, metabolic rate)
- Environmental factors: conditions of the thermal environment (including indoor air temperature, mean radiant temperature, air speed and relative humidity)

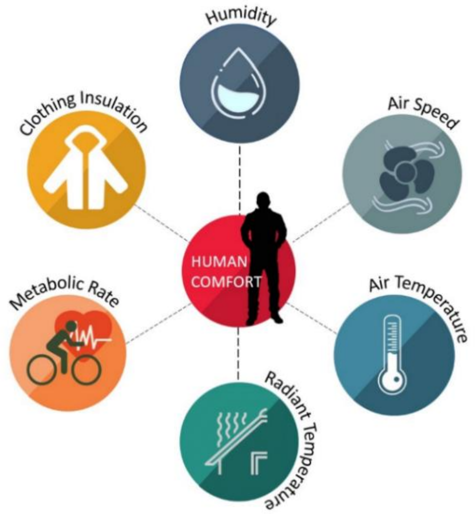


Figure 2: Environmental and Physical factors that influence human factors
Source: Role of CFD in Evaluating Occupant Thermal Comfort, (2023).

3.Method of study

- The heat stress of the environment will be determined by getting the Bioclimatic data of University of Lagos, this includes: air temperature, mean radiant temperature, relative humidity, radiation and air velocity that were collected from the Geography Department of the University of Lagos. These data were then analysed to determine the environmental heat stress for the area under study.
- Sample Games from players will be collected by “selected random sampling method”. Since the demography is zoned according to climatic factors, 15 games will be collected from chess players that come from the Hot Dry Regions, and another 15 games from those that emanate from the Hot Humid regions. These same 30 players games are analysed using Stockfish16® open-source chess engine, for the two periods, when the power is on and active cooling method is used, and a comparative analysis of the performance is done when the passive cooling method of the hall is used (when there is power outage). The comparative analysis would be computed. This is to test the hypothesis H_1. That the quality of the games diminished with higher heat load in the hall.
- The building will be measured, considerations will be made on the materials used for the walls, roofs, windows and door openings on a larger scale of heat load. The number of players in the hall, the heat generating equipment like laptops, printers, lighting bulbs will be all taken into cognisance in. The HVAC available in the hall are documented also. These variables will be simulated using the *Graphisoft EcoDesigner STAR®.* Software for complete thermal evaluation simulation.
- Structured questionnaires will be shared in the “NUGA 2022 chess chatroom” as well as other chess online fora having players, coaches and officials, on WhatsApp®, using Google© doc form with thermal linear scale questions. The PMV as well as other comfort variables that determine the Thermal sensation vote (TSV) of the respondents in the hall will be recorded from these data.

  Interviews about perceptions on what an ideal indoor sports hall for chess is generated from a focus group that has International Masters of chess for the player category, and International Arbiters of chess from the official category. Finally, chess coaches that have been able to go to international tournaments with their players in the last category. The selection was done based on their international tournaments’ exposure and experiences in ideal playing hall environments. These questionnaires and interviews will be downloaded, transcribed and analyzed using NVivo® qualitative analysis software.

4.Game of chess and its indoor game requirements

Chess first appeared in India about the 6th century CE. By the 10th century it had spread from Asia to the Middle East and Europe.(Britannica, 2021). The Nigerian University Games Association sees chess as a brain tasking game and the need for it to be inculcated in games was agreed since the inception in 1966 (Nigerian University Games Association, nuga.com.ng). It has been a high medal winning event in the game with 16gold medals, 16 Silver and 16bronze in the offing. Very few works have been done by researchers on heat gain in chess game halls. The only reliable document, to this effect, is the handbook by the Federation International de Echess (FIDE) where the basic guidelines for playing venues approved has these sections that deal with the playing comfort of the players (FIDE Handbook C. General Rules and Technical Recommendations for Tournaments / 01. Basic Guidelines for playing venues of FIDE Top-Level Tournaments, FIDE, 2022)

1.1 It should ideally be situated in a hotel where players are accommodated or nearby.

1.2 It should not be less than 5n square metres in size, where n is the number of players.

1.3 Tables, electronic boards, pieces and clocks shall be of the highest quality according to FIDE standards (Handbook Art C.02).

1.4 The temperature should be 21 – 23°C.

1.5 Lighting shall be at least 450 lux. Lighting should not cast shadows or cause pinpoints of light to be reflected from the pieces. (Approved by FIDE Council on 25/11/2022)

It is clear from the aforementioned indicators that the only conditions needed for player comfort are distance, lighting, and temperature. Other factors that influence indoor air quality (IEQ) and can cause discomfort from the heat stress, were not appropriately taken into account. Through careful analysis of the local microclimate data, as well as the physiology of player’s reaction, the research has been able to close this gap.

5.The study of the event environment and hall

A total of 14 universities (74 players) for the male event (https://chess-results.com/tnr620727.aspx?lan=1), and 12 Universities (62 players), for the female event (https://chess-results.com/tnr620733.aspx?lan=1&art=2&rd=2-) came to battle it out for medals. The total number of officials and coaches was thirty-three (33). The event occurred from 20th to the 27th of March, 2022 at the University of Lagos Women Society (ULWS) School Hall, that is located at 6˚ 30' 52.97" N, 3˚ 23' 46.19" E, and at the altitude of 201.47meters above sea level, as shown in Figure 3. It is near the Unilag Alumni Jubilee Hall and opposite the University Medical Centre (Fig.3).

Figure 3: Google map location of the University of Lagos Women Society Hall.

From the works of (Ogunsote & Prucnal-Ogunsote, 2001) and (Komolafe & Agarwal, 1987) a composite climatological zoning map was produced by (Ajibola, 2001)

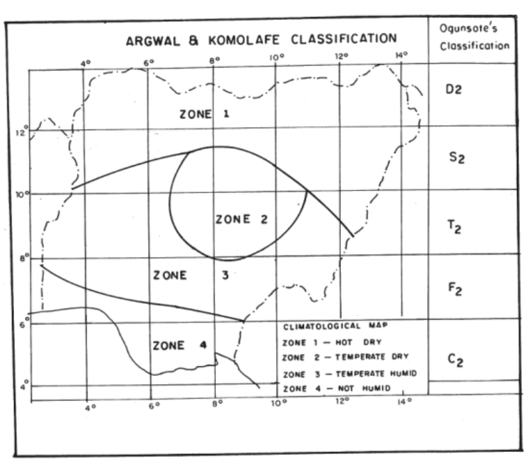


Figure 7: Classification of Nigerian climate
Source: Ajibola,K. (2001) modified from Ogunsote (2001) and Komolafe (1987)

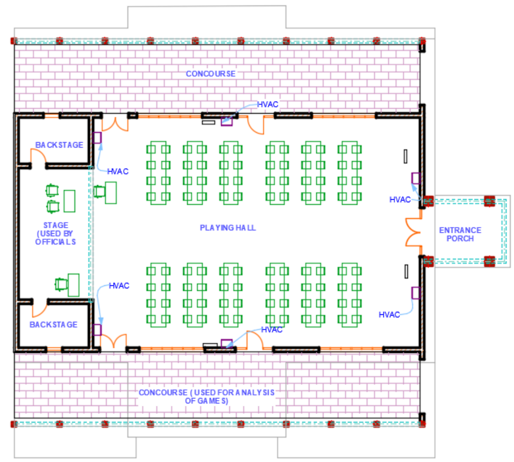


Figure 4: Floor plan of the hall.

Figure 5: Side elevation.

Figure 6: 3D view.

The playing hall has a floor area of Floor area 1,318.6m^2. (Fig. 4). The views of the building show the elevations and perspective (Fig. 5 & 6). The roof is barrel shaped made up of long span aluminum sheets with wooden trusses (Fig. 6), and having PVC ceilings. The Wall is made of composite reinforced concrete and sand/cement blockworks.

6. Observation, analysis and results discussion

6.1 Thermal comfort analysis

In the prediction of thermal comfort, responses of using randomly selected sample of those that filled the questionnaires (https://docs.google.com/forms/d/1FvfjXxObjjsgjbF

Ujald3syWzuLFWLkod7zewh6cp5U/prefill), 40 of the players in the hall area are examined. The respondents are asked about their thermal sensation at three different times of the year using (2015 ASHRAE Handbook : Heating, Ventilating, and Air-Conditioning Applications) PMV scale of thermal comfort. This included the temperature, humidity and air-velocity vairables. The first period is when the hall is being ventilated by passive means, the second is when it's ventilated by active means. The results showed that in a total of 40 responses, 8 which is 20% are from University of Jos, close followed by University of Lagos with 17%. (Fig 8). The thermal sensation vote from Figures 11-15 showed a mixture of heat gain when passive cooling is employed, and conditions like humidity and draftiness were not pleasing to the vast majority. The demography of the occupants based on age is shown in Figure 16. It proved that most of them are from age 15-25.

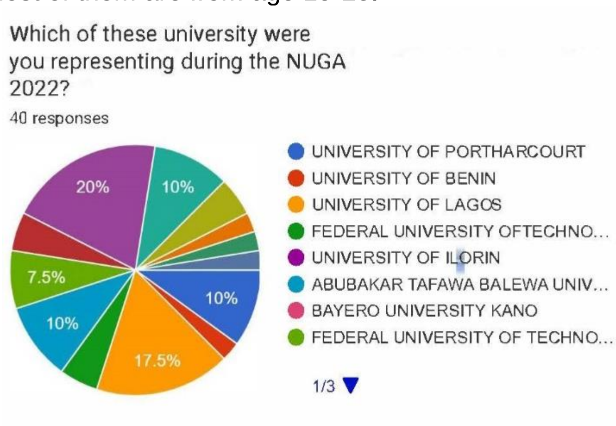


Figure 8: Respondents schools and their percentage.

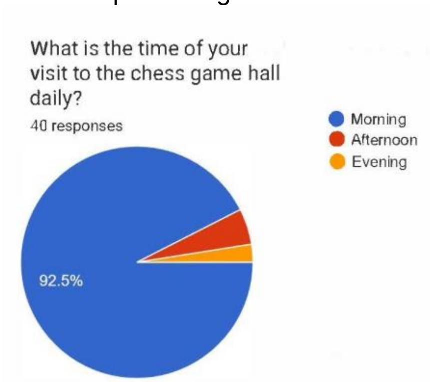


Figure 9: Respondents visitation time,

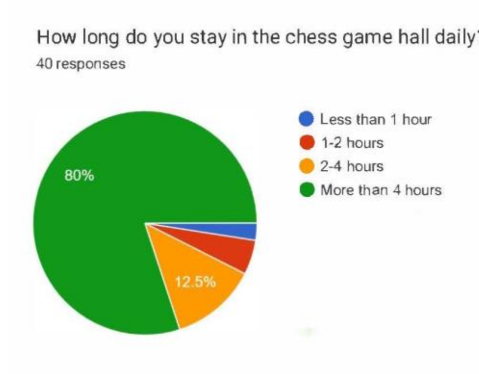


Figure 10: Respondents duration.

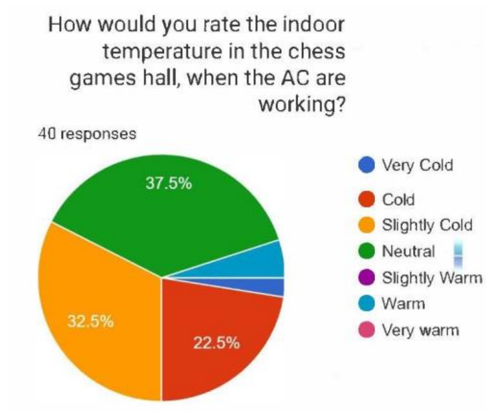


Figure 11: Respondents thermal sensation When AC is on.

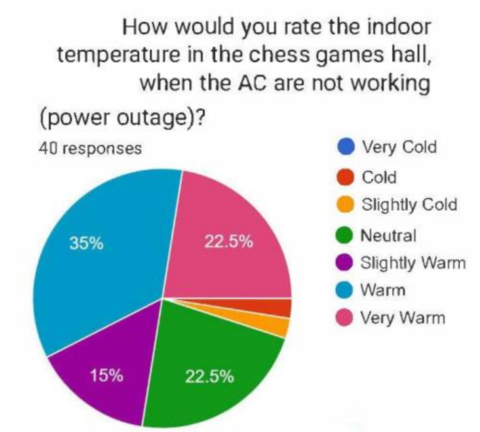


Figure 12: Respondents thermal sensation When AC is off.

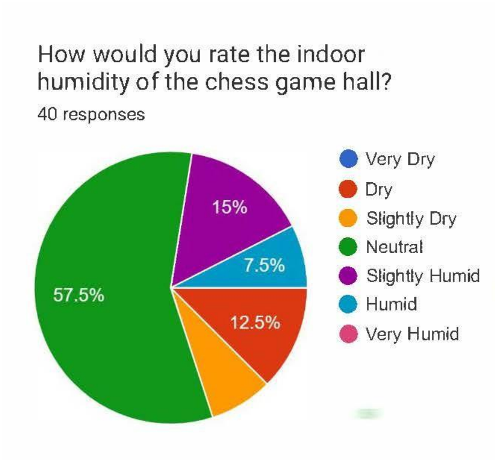


Figure 13: Respondents humidity sensation.

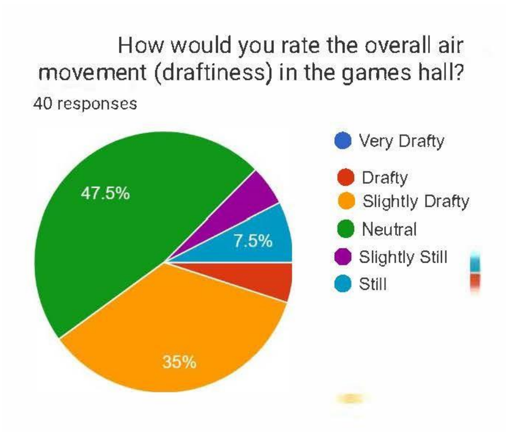


Figure 14: Respondents draftiness sensation.

Figure 15: Respondents thermal comfort.

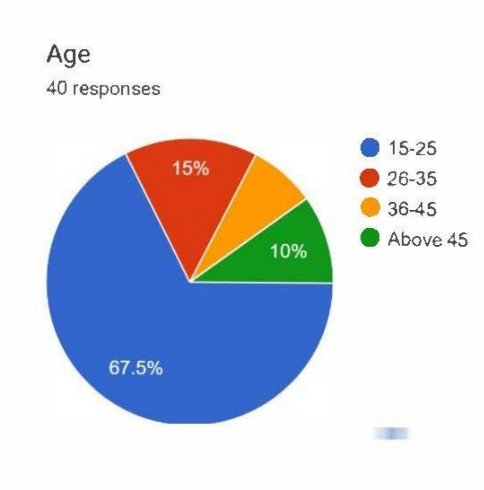


Figure 16: Respondents age.

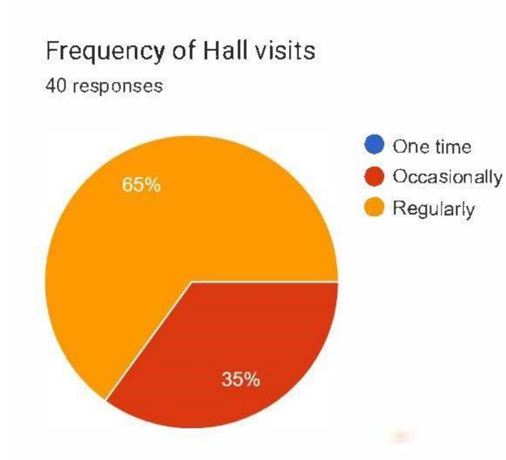


Figure 17: Respondents Frequency of hall visit.

There were 3 focus group discussions (FGDs) held in this research. Focus group 1 had 3 participants from chess players, focus group 2 also had 3 participants from chess arbiters, and focus group 3 equally had 3 participants from chess coaches, making 9 participants in total. The analysis was done by Nvivo 14® qualitative data analyzer. The three themes are:

- **Athlete Experience and Comfort**: Explore the experiences and comfort levels of chess players and other individuals using the indoor sports hall during hot weather. Consider factors such as temperature perception, humidity, air circulation, and comfort-related challenges. Interviews and surveys with athletes and visitors can provide insights into their experiences.
- **Adaptive Strategies and Coping Mechanisms**: Investigate the adaptive strategies and coping mechanisms employed by individuals and facility

managers to deal with thermal heat stress in the indoor sports hall. This could include examining how the facility is designed to mitigate heat, the use of cooling systems, scheduling adjustments, and access to hydration resources. Qualitative interviews and observations can help uncover these strategies.

- **Impact on Performance and Participation:** Analyze how thermal heat stress affects chess performance and participation in indoor sports hall activities. Explore whether heat-related discomfort or health concerns influence attendance, concentration, and the overall experience of chess players and spectators. Interviews with chess players and organizers can shed light on these impacts.

The result of the interviews done and analyzed are shown below:

6.2 Athlete experience and comfort

Overall thermal comfort in the indoor sports hall for chess On a scale of 1 to 10, with 1 being extremely uncomfortable and 10 being extremely comfortable, the participants returned out come as is on Figure 18.

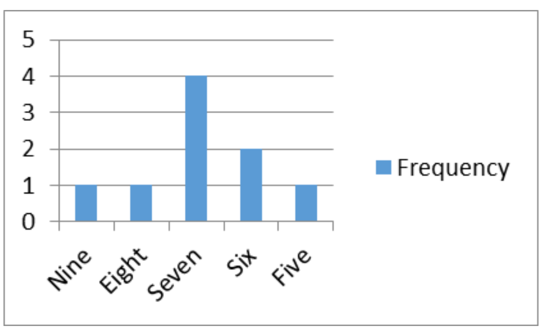


Figure 18: Overall thermal comfort rating in the indoor sports hall for chess on a scale of 1 to 10.

i. **Description of initial impressions of the temperature and environment inside the sports hall for chess**
Most of the participants (across the three focus groups) described their initial impressions of the temperature and environment inside the sports hall for chess as fine and okay *"…very okay…temperature doesn't affect me much…,"* a chess arbiter said. However, some few had the impression that it was somewhat hot, as stated by a player: *"It seemed slightly hot."* (See figure 19).

Figure 19: A Word Cloud Showing the description of initial impressions of the temperature and environment inside the sports hall for chess.

ii. **Description of the temperature (feeling too hot, too cold, or just right) in the indoor sports hall while playing chess**
A Word cloud revealed different descriptions of the temperature in the indoor sports hall while playing chess (See figures 19 & 20). While other participants found the indoor sports hall **temperature as** just right and okay, there were others that found it was hot (figure 20). A chess player said it was *"…just right"* and another said it was *"a bit hot." "….I get hot first but subsequently I become normal.",* Another chess player added. This varying description og the temperature were also the case with other focus groups (arbiters and coaches,) whereby some found the hall to be just okay, however to some, it was hot.

Figure 20: Description of the temperature in the indoor sports hall while playing chess.

iii. **How the temperature inside the hall affect focus and concentration during games.**
Participants from the three focus groups were affected by temperature inside the hall in different ways (Figure 21). However, the players and coaches seemed to be experiencing similar issues of additional stress and loss of focus on the game /players. The loss of focus was due to double mindedness while one was making an effort to make selves comfortable. In the case of the arbiters, they tended to not to have much issue with the temperature with respect to their tasks. *"My work is not as tasking as the players, since I put in scores and do mechanical judgments. So it didn't affect my concentration,"* an arbiter said.

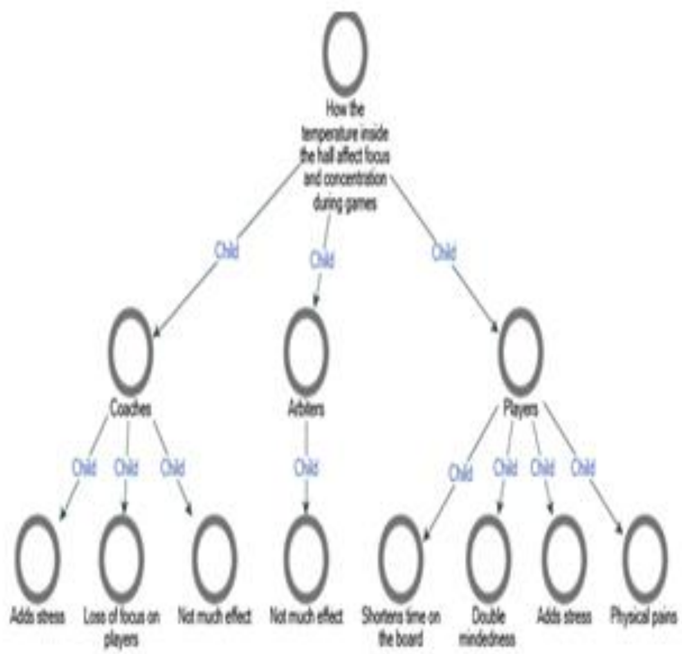


Figure 21 How the temperature inside the hall affect focus and concentration during games.

iv.Issues with air quality or ventilation in the chess playing area
While some few participants did not have any Issues with air quality or ventilation in the chess playing area, many have observed issues as in figure 22. There were problems with the air conditioning system not functioning/ switched on, bad odor from bodies due to the stuffy environment, and poor and imbalance ventilation. "…Yes the circulation for cooling has issues. Some parts don't get the right cooling temperature," a participant said. There were also observed varying air quality/ventilation conditions; in the sense that, sometime the condition would be favourable and sometimes not.

Figure 22: Issues with air quality or ventilation in the chess playing area.

v. Air inside the hall and discomfort experienced due to poor ventilation

Figure 23 Air inside the hall and discomfort experienced due to poor ventilation

The air inside the hall was generally regarded as fresh as seen in figure 23; however; there were some issues such as inconsistences of ensuring the good air conditioning of the hall. A player said: "…It is sometimes fresh, but definitely a difference is noticed when you come from the outdoors,"

vi.The comfort ability of humidity in the indoor sports hall while playing chess

Figure 24: The comfort ability of humidity in the indoor sports hall while playing chess

The humidity was regarded as somewhat comfortable (figure 24). "It was relatively okay," A participant said; however, a coach stated that the humidity sometimes makes his players uncomfortable as they reported to him/her. "My players said it makes them uncomfortable…"
vii. Discomfort or any issues related to humidity
Most participants (5) have acknowledged that they had had issues discomfort of some kind with respect to humidity, while other (4) disclosed not having any issue. For those that had, the issues were with the AC switched off, sticky body,

viii. Adaptive Strategies and Coping Mechanisms
Do you bring any personal comfort items (e.g., blankets, fans, or extra clothing) to the chess games in the indoor sports hall
None of the participants ever brought any personal omfort items (e.g., blankets, fans, or extra clothing) to the chess games in the indoor sports hall.

ix.How the items help in maintaining thermal comfort during games
The participants never used any personal comfort items to help in maintaining thermal comfort during games.

x. The distraction or hindrance of extreme temperature conditions to chess games in this indoor sports hall
"Yes…" some participants acknowledged that they had experienced the distraction or hindrance of extreme temperature conditions in the indoor sports hall. However, there were those that never had any distraction by the reason of extreme temperature conditions.

xi.Coping with temperature-related distractions
These mechanisms were found to be adopted by the players, while the arbiters and coaches reported not to apply any coping mechanism (figure 25).

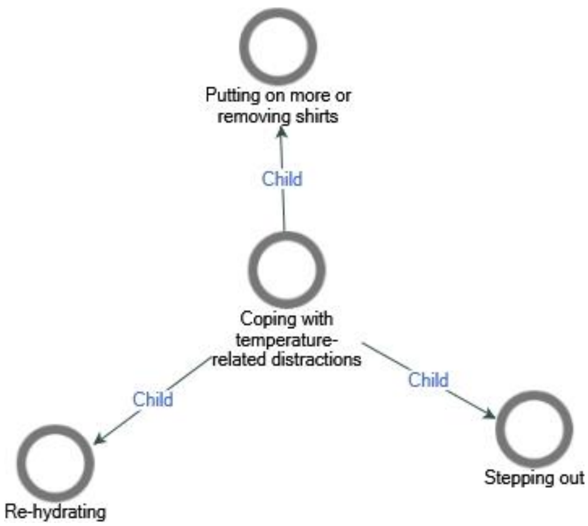
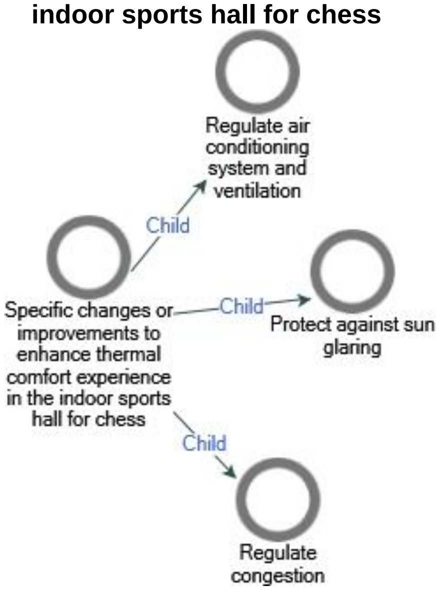


Figure 25: Temperature related distractions coping mechanisms.

xii. **Specific changes or improvements that enhance thermal comfort experience in the indoor sports hall for chess**



effect of heat stress on the game, the games of the same fifteen players are analyzed using Stockfish 16®
software, and the results are as shown in Figure 27.

Figure 26 Suggested improvements for indoor sports hall.

xiii. **Design or operational modifications to make the environment more suitable for chess players**
Most of the respondents seemed to align with Figure 26.

6.3 Impact on performance and participation

Many of the respondents have been analyzed by the games quality decline as shown in Figure 26, due to thermal stress.

Game played analysis.

To analyze the games played in chess, one needs to understand the methodology employed by the computer. The following terminologies need to be clearly understood to help in this:

- Inaccuracies: These are moves that deviate from the norms as prescribed by the computer.
- Mistakes: These moves are not good. Better moves are in the offing.
- Blunders: They are higher mistakes that are fatal. If the opponent notices them, it might result to an outright loss.
- Average centi pawns lost: how many hundredths of a pawn your moves differ from the engine best move. The closer to zero your score, the better you are.

- Accuracy: This is playing the computer recommended move.

The games quality can therefore be taken as a summation of inaccuracies down to the average centi pawn lost. The closer this value is to zero, the more quality the game. To really comprehend the

	POWER IS AVAILABLE (temp 21-24^{0}C)						POWER IS OUT (temp above 24^{0}C)					
	Inaccuraces	Mistakes	Blunders	Average centi pawns lost	TOTAL LOW QUALITY	Accuracy (%)	Inaccuraces	Mistakes	Blunders	Average centi pawns lost	TOTAL LOW QUALITY	Accuracy (%)
PLAYER 1	7	2	1	63	73	68	8	1	2	73	84	57
PLAYER 2	4	1	2	45	52	66	3	4	1	63	71	62
PLAYER 3	3	1	0	51	55	82	6	3	1	87	97	64
PLAYER 4	4	2	1	42	49	74	5	2	0	34	41	65
PLAYER 5	5	1	0	32	38	45	4	1	1	45	51	57
PLAYER 6	3	1	0	48	52	38	5	0	0	56	61	68
PLAYER 7	6	1	1	45	53	67	4	3	1	61	69	53
PLAYER 8	3	0	0	33	36	79	10	5	1	58	74	76
PLAYER 9	2	0	0	35	37	82	4	3	0	49	56	79
PLAYER 10	2	1	2	56	61	71	6	1	3	78	88	34
PLAYER 11	12	3	1	97	113	34	15	5	4	89	113	26
PLAYER 12	8	2	1	53	64	58	7	2	2	67	78	42
PLAYER 13	3	2	0	67	72	69	5	3	1	56	65	71
PLAYER 14	6	2	2	49	59	53	7	1	3	78	89	64
PLAYER 15	5	1	2	68	76	72	4	1	0	69	74	65
TOTAL	73	20	13	784	890	958	93	35	20	963	1111	883

Figure 27: Comparison of games played in two different scenarios.

The resultant decline in the cumulative quality of games and accuracies has a direct relationship to the thermal stress experienced by the chess players.

6.4 Energy evaluation analysis

The building was analyzed using Graphisoft EcoDesigner STAR®. The outputs are shown in Figure 28.

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1) Key Values

General Project Data

Project Name:	Unilag WSH
City Location:	Lagos
Latitude:	6° 30' 5" N
Longitude:	3° 23' 59" E
Altitude:	207.00 m
Climate Data Source:	Strusoft server
Evaluation Date:	3/8/2022 1:19:37 PM

Heat Transfer Coefficients	U value	[W/m²K]
Building Shell Average:	**1.09**	
Floors:	**--**	
External:	**1.00 - 1.00**	
Underground:	**--**	
Openings:	**2.11 - 3.45**	

Building Geometry Data

Gross Floor Area:	**1318.61**	m²
Treated Floor Area:	**1276.56**	m²
External Envelope Area:	**1201.41**	m²
Ventilated Volume:	**17425.02**	m³
Glazing Ratio:	**2**	%

Building Shell Performance Data

Infiltration at 50Pa:	**0.31**	ACH

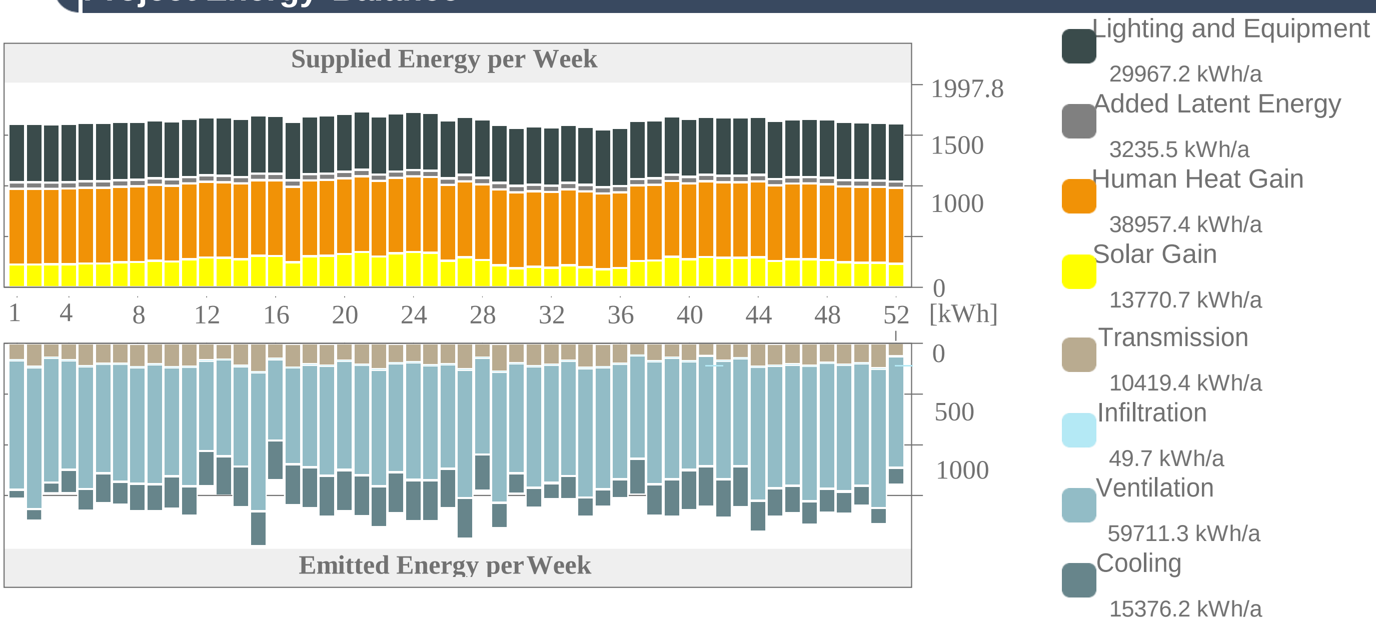
b) Specific Annual Values

Net Heating Energy:	**0.00**	kWh/m²a
Net Cooling Energy:	**12.05**	kWh/m²a
Total Net Energy:	**12.05**	kWh/m²a
Energy Consumption:	**47.24**	kWh/m²a
Fuel Consumption:	**39.75**	kWh/m²a
Primary Energy:	**135.84**	kWh/m²a
Fuel Cost:	**--**	GBP/m²a
CO_2 Emission:	**8.59**	kg/m²a

Degree Days

Heating (HDD):	**666.36**
Cooling (CDD):	**5715.19**

Project Energy Balance



1) *Thermal Blocks*

Thermal Block	Zones Assigned	Operation Profile	Gross Floor Area m²	Volume m³
001 Sample Thermal Block	1	Sports hall	228.74	2900.86
001 New Thermal Block	1	Sports hall	483.06	14524.16
Tota l:	**2**		**1318.61**	**17425.02**

01 Sample Thermal Block - Key Values

Geometry Data

Gross Floor Area:	**228.74**	m²
Treated Floor Area:	**212.52**	m²
Building Shell Area:	**254.55**	m²
Ventilated Volume:	**2900.86**	m³
Glazing Ratio:	**23**	%

Internal Temperature

Min. (06:00 Jan. 15):	**9.15**	°C
Annual Mean:	**26.95**	°C
Max. (13:00 Apr. 20):	**41.28**	°C

Unmet Load Hours

Heating:	**54**	hrs/a
Cooling:	**3116**	hrs/a

Heat Transfer Coefficients	U value	[W/m²K]
Floors:	**-**	
External:	**1.00 - 1.00**	
Underground:	**-**	
Openings:	**2.11 - 3.45**	

Annual Supplies

Heating:	**0.00**	kWh
Cooling:	**5224.75**	kWh

Peak Loads

Heating (01:00 Jan. 01):	**0.00**	kW
Cooling (21:00 Mar. 15):	**1.50**	kW

001 New Thermal Block - Key Values

Geometry Data		
Gross Floor Area:	**1089.88**	m²
Treated Floor Area:	**1064.04**	m²
Building Shell Area:	**946.86**	m²
Ventilated Volume:	**14524.16**	m³
Glazing Ratio:	**1**	%

Internal Temperature		
Min. (06:00 Jan. 14):	**7.41**	°C
Annual Mean:	**26.39**	°C
Max. (13:00 Apr. 20):	**42.64**	°C

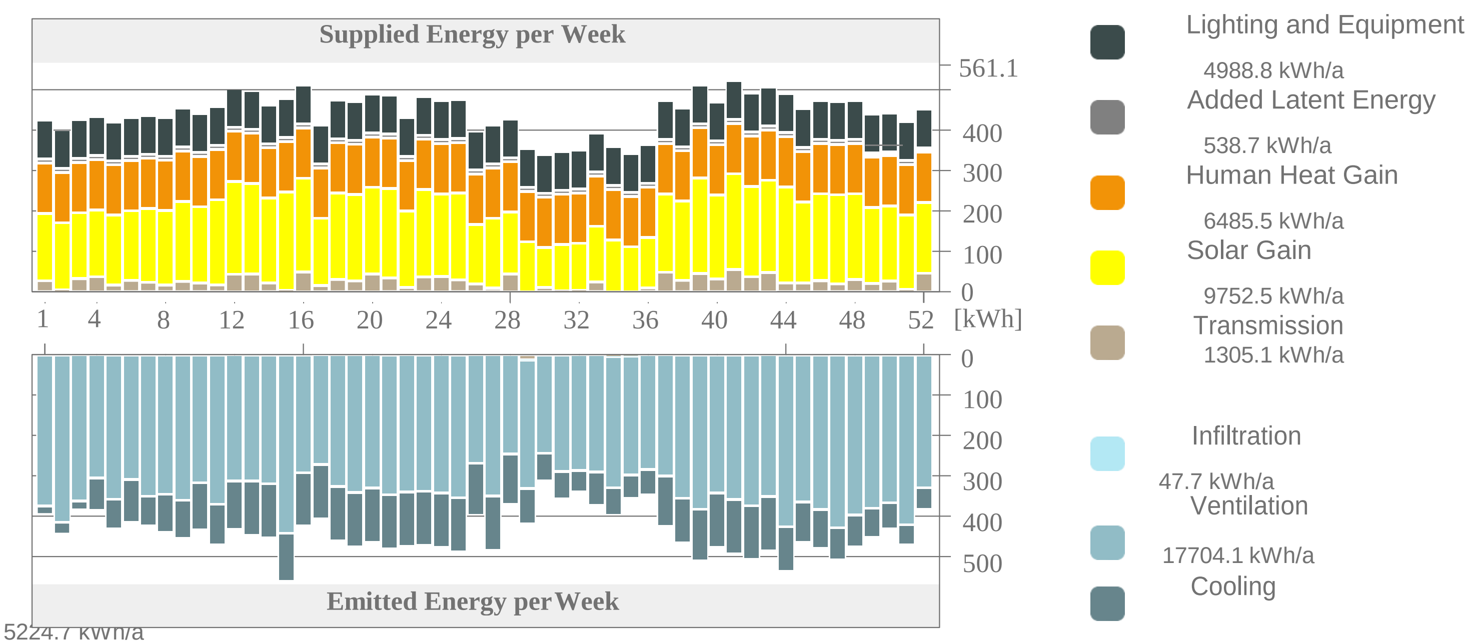
Unmet Load Hours		
Heating:	**105**	hrs/a
Cooling:	**3050**	hrs/a

Heat Transfer Coefficients	U value	[W/m²K]
Floors:	**-**	
External:	**1.00 - 1.00**	
Underground:	**-**	
Openings:	**2.11 - 3.32**	

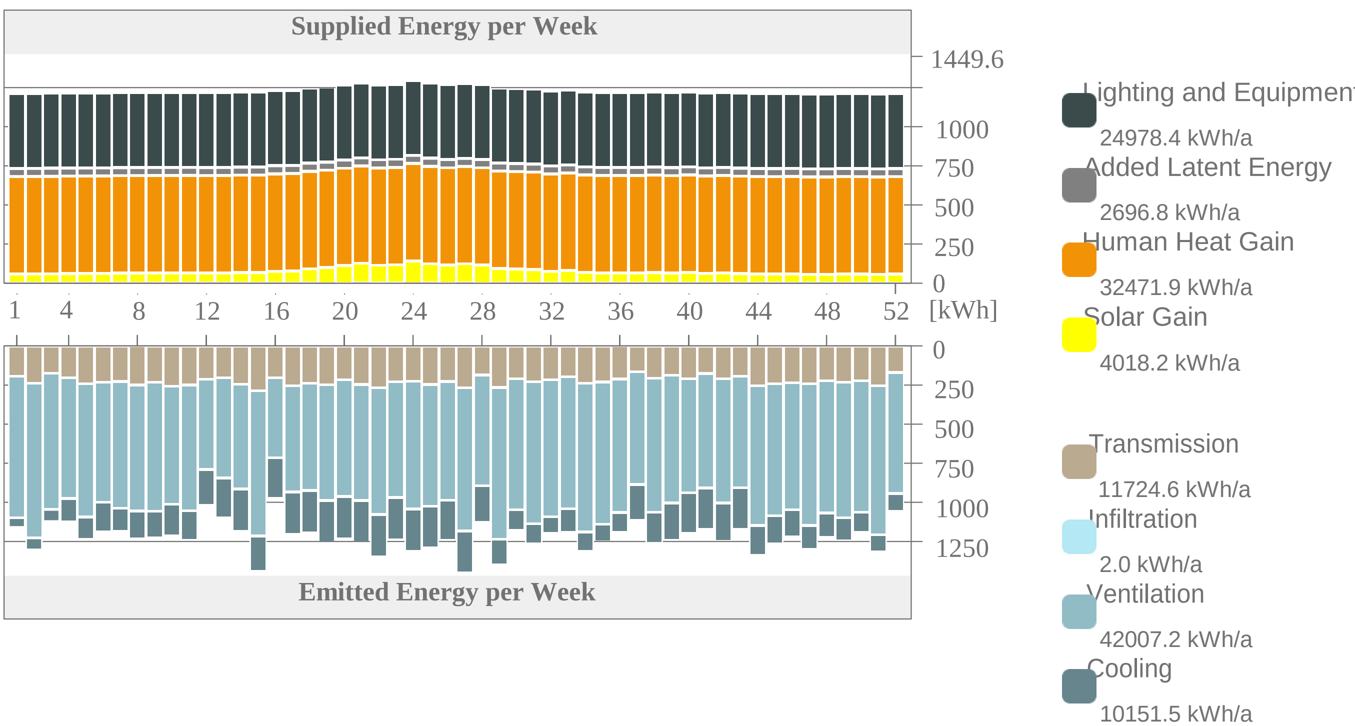
Annual Supplies		
Heating:	**0.00**	kWh
Cooling:	**10151.49**	kWh

Peak Loads		
Heating (01:00 Jan. 01):	**0.00**	kW
Cooling (21:00 Jun. 01):	**3.00**	kW

001 Sample Thermal Block Energy Balance



1) *001 New Thermal Block Energy Balance*



2) *Daily Temperature Profile*

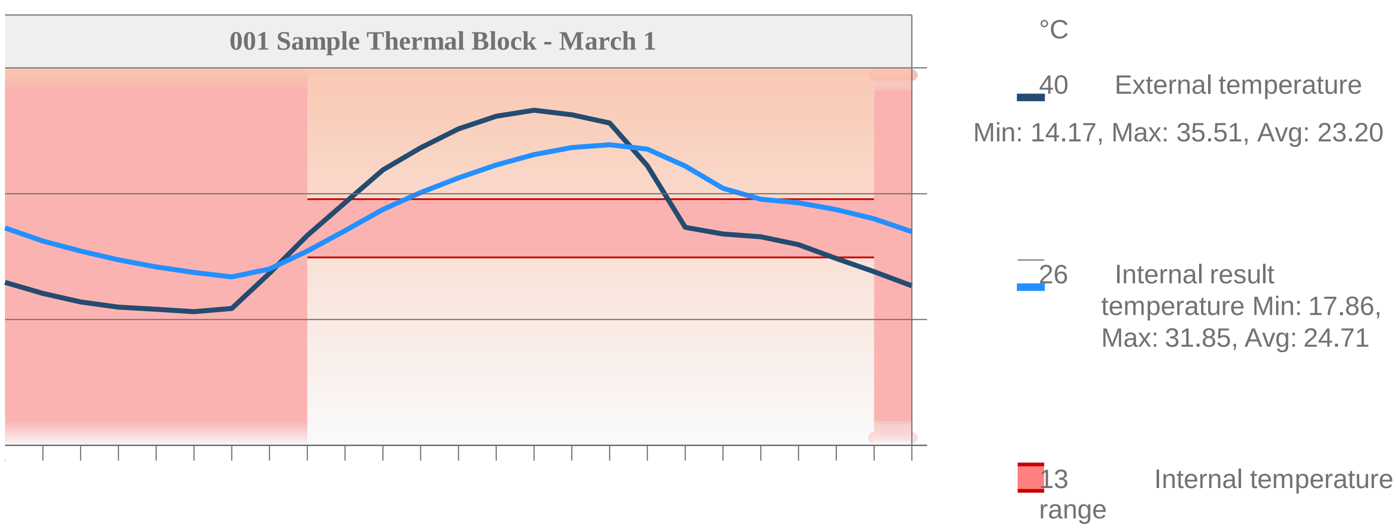


Figure 28: Energy evaluation of University of Lagos Women Society Hall.

The analysis of the above showed a great energy used to cool the indoor sports hall of 10151.49 KWh annually. This is not sustainable.

The analysis of the above showed a great energy used to cool the indoor sports hall of 10151.49 KWh annually. This is not sustainable.

Conclusion

The analysis of the environment indicates that the heat stress of the indoor hall is high. Examining the respondents show that heat stress affects their performance. The stress factors if eliminated will create a conducive environment that is unbiased and productive to the athletes. The sustainability of indoor sports hall needs to be investigated properly by taking other parameters of indoor air quality like air purity and cleanliness.

Recommendations

The above findings have shown that other means of ventilation can be explored in designing indoor sports hall. These include the well-known ventilation by stack method, and other wind-catchers' method like the qanat. Also, in designing indoor sports hall. These passive methods have very little or no carbon footprint. Knowledge of making the hall thermally comfortable should be made a criterion for producing schemes and constructing he buildings. Lastly, all stakeholders, that is, the players, the organizers as well as officials should partake in the design stages of indoor sports hall.

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