
EVALUATION OF THERMAL COMFORT STRATEGIES IN REHABILITATION AND WELLNESS CENTRES

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ABSTRACT

Thermal comfort is a critical component of rehabilitation and wellness-centre design because physically active users generate substantial metabolic heat and may be vulnerable to heat stress. This study evaluated thermal comfort strategies in selected rehabilitation, wellness, and gymnasium facilities in Ibadan, Nigeria, with the aim of informing the design of the Adewole Rasheed Ladoja Gymnasium. A mixed-method approach combined questionnaire survey, field observation, architectural documentation and case-study assessment. A sample of 307 responses was drawn from a weekly population estimate of 1,340 users across seven purpose-built facilities. Findings showed that the facilities relied strongly on basic passive strategies, particularly mechanical fans (91.0%), shading devices (88.0%), large operable windows (86.0%), daylighting (85.0%), high ceilings (84.0%) and cross-ventilation (81.0%), while wall insulation (49.0%), thermal-mass materials (46.0%) and thermostats (41.0%) were less common. Perceived effectiveness was generally positive, with daylighting and combined passive-mechanical systems recording the highest average mean values (AMV = 4.12), while comfort during high humidity (3.50), physical activities (3.59), and the reasonableness of cooling energy consumption (3.38) remained weaker. Outdoor temperature (4.34), solar radiation (4.32), relative humidity (4.28), ventilation design (4.25), and air movement (4.23) were the most influential thermal-comfort factors. Major management challenges were the need for additional passive cooling (4.36), adverse outdoor climatic conditions (4.32), power outages (4.26), limited funding (4.15), and high energy costs (4.08). The study concludes that thermal comfort in the sampled facilities is generally acceptable but remains vulnerable under high humidity, intense activity and energy constraints. It recommends integrated climate-responsive design based on cross-ventilation, shading, appropriate orientation, insulated and reflective envelopes, landscaping, energy-efficient mechanical systems, regular maintenance, and reliable backup energy for the proposed gymnasium.

Keywords: Thermal comfort; Rehabilitation centre; Wellness centre; Gymnasium; Passive cooling; Adaptive thermal comfort; Ibadan

I. INTRODUCTION

Architecture in rehabilitation and wellness environments performs more than a sheltering function because the physical environment can influence comfort, safety, psychological well-being and the effectiveness of therapy. In gymnasium spaces, this relationship becomes particularly important because exercise raises metabolic heat production and increases the demand for effective heat dissipation. The thesis frames thermal comfort as essential to safe and effective rehabilitation and notes that high temperature and humidity in Ibadan can increase thermal stress, especially during physical activity (Notley et al., 2019; WHO, 2023).

Thermal comfort is conventionally understood as a state of satisfaction with the thermal environment. ASHRAE (2020) defines it as “that condition of mind which expresses satisfaction with the thermal environment.” In warm-humid settings, comfort is strongly affected by air movement, humidity, solar exposure, clothing, activity level and occupants’ adaptive behaviour. Adaptive thermal comfort research indicates that naturally ventilated occupants may accept somewhat higher temperatures when air velocity is sufficient (Rupp et al., 2018; de Dear et al., 2021). This is especially relevant to gymnasiums, where increased air movement can support convective and evaporative heat loss during exercise (Tartarini & Schiavon, 2020).

The problem is compounded by energy insecurity. Mechanical air-conditioning can provide immediate cooling, but dependence on active systems increases energy demand and exposes facilities to operational disruption where electricity is unreliable. The thesis therefore emphasizes passive and hybrid responses, including cross-ventilation, solar shading, reflective roofing, insulation, landscaping and climate-responsive orientation (Ascione et al., 2021; IEA, 2022; Santamouris, 2020). The research is positioned within a gap in Nigerian thermal-comfort studies, which have more frequently examined residential and office buildings than high-metabolic rehabilitation gymnasiums.

1.1 Aim and Objectives

The aim of the study was to evaluate thermal comfort performance in selected gymnasium, rehabilitation and wellness centres. The objectives were to:

- i. examine existing thermal comfort strategies adopted in selected rehabilitation and wellness centres;
- ii. assess the effectiveness of passive and mechanical systems in achieving indoor thermal comfort for physically active occupants;
- iii. identify architectural and environmental factors influencing thermal comfort performance; determine major challenges associated with thermal comfort management within energy-constrained contexts and;
- iv. develop context-specific design recommendations and passive thermal-comfort strategies suitable for the proposed Adewole Rasheed Ladoja rehabilitation and wellness centre.

1.2 Problem Statement

Rapid urbanization, a hot-humid climate and the high metabolic demands of exercise create a difficult thermal environment for rehabilitation and wellness facilities in Ibadan. The thesis identifies inadequate orientation, weak solar control, insufficient ventilation and inappropriate glazing as recurring weaknesses that can increase heat gain and reduce indoor comfort. These challenges are intensified by climate change, unstable electricity supply and the cost of mechanical cooling (IPCC, 2021; IEA, 2022).

The problem is not simply the absence of cooling equipment. Existing facilities may provide fans and air-conditioning but still experience discomfort during high humidity and intense physical activity. The underlying issue is the limited integration of architectural form, envelope design, ventilation, shading and operational systems into a coherent thermal strategy. This is significant because rehabilitation users may include patients and other physically active occupants whose thermal tolerance differs from that of sedentary building users.

II. LITERATURE REVIEW

2.1 Thermal Comfort in Rehabilitation and Wellness Environments

Thermal comfort in rehabilitation and wellness environments is closely linked to health, physical performance and perceived environmental quality. The thesis establishes that indoor thermal conditions can affect physiological and psychological outcomes and that thermally uncomfortable environments may undermine the experience of exercise and recovery (Tartarini & Schiavon, 2020; Allen et al., 2020). In a rehabilitation gymnasium, the thermal environment must therefore support both ordinary occupancy and periods of elevated metabolic activity.

The literature indicates that thermal stress is influenced by the combined action of air temperature, humidity and air velocity. Notley et al. (2019) demonstrate the relevance of heat exposure during exercise, while Rupp et al. (2018) explain that natural ventilation and air movement can widen acceptable temperature ranges. This adaptive perspective is useful for Ibadan because occupants are not passive recipients of climate; they adapt through posture, clothing, activity patterns and the use of windows and fans. de Dear et al. (2021) similarly support adaptive approaches that respond to occupant behaviour and context rather than relying solely on fixed temperature thresholds.

For rehabilitation spaces, comfort must also be considered therapeutically. The thesis connects climate-responsive architecture with patient and user well-being, noting the value of daylight, nature, airflow and user control (Ulrich et al., 2020; WHO, 2023). This means that thermal design should not be reduced to cooling capacity alone. Instead, a successful gymnasium should provide a stable and adaptable indoor environment through architectural form, passive cooling and low-energy mechanical support.

2.2 Passive Thermal Comfort Strategies for Warm-Humid Climates

Passive thermal design seeks to reduce unwanted heat gain and increase useful heat removal before mechanical cooling is required. In warm climates, the literature identifies orientation, cross-ventilation, solar shading, roof treatment, thermal mass and landscape design as major strategies (Ascione et al., 2021). The thesis emphasizes that these measures are particularly important in Nigeria because unstable electricity supply can make mechanically intensive buildings unreliable and expensive to operate (IEA, 2022).

Natural ventilation is particularly significant in gymnasiums because physical activity increases metabolic heat production. Cross-ventilation can be achieved through opposing operable openings, while stack ventilation uses buoyancy forces to exhaust warm air through high-level vents, roof monitors or clerestories (Rupp et al., 2018; Ascione et al., 2021). The literature also suggests that high ceilings can support vertical heat stratification and that perforated façade systems can combine airflow with solar control (Olawumi & Chan, 2019).

Solar control is another core requirement. Deep overhangs, brise-soleil and adjustable louvers can reduce direct solar radiation, while high-albedo roofs and reflective materials can reduce surface temperatures and indoor heat gain (Alwetaishi, 2019; Santamouris, 2020).

Landscaping can supplement building-scale measures by shading exposed surfaces and improving microclimatic conditions through evapotranspiration. The combined lesson is that passive strategies work best as an integrated system rather than as isolated features.

2.3 Adaptive Thermal Comfort and Bioclimatic Design

Adaptive thermal comfort recognizes that acceptable indoor conditions depend partly on the interaction between people, behaviour and climate. de Dear et al. (2021) argue for renewed attention to adaptive models in buildings where occupants have meaningful opportunities to respond to environmental conditions. In naturally ventilated buildings, users can modify windows, clothing and activity patterns, making a fixed temperature target less representative of actual comfort.

The bioclimatic approach extends this idea to architectural decision-making by treating climate as an active driver of form and orientation. The thesis identifies sun path, prevailing wind, humidity and solar exposure as key inputs into the design of a gymnasium for Ibadan. Orientation along a suitable axis, minimized east-west exposure, façade permeability and coordinated shading and ventilation can reduce cooling demand while improving comfort (IPCC, 2021; Ascione et al., 2021).

Bioclimatic design is also relevant to resilience. A building that remains usable during partial or total loss of grid electricity provides a stronger level of passive survivability than a facility whose comfort depends entirely on mechanical cooling. In Nigeria, this resilience dimension connects thermal comfort with energy affordability, service continuity and public health, making passive design a practical requirement as well as a sustainability preference (IEA, 2022; UNEP, 2023).

2.4 Thermal Comfort and Therapeutic Architectural Design

Therapeutic architecture considers the built environment as an active contributor to health and recovery. The thesis relates thermal conditions to exercise tolerance, stress and user satisfaction and argues that daylight, nature and controlled airflow can support both physiological and psychological well-being (Ulrich et al., 2020; WHO, 2023). In rehabilitation environments, thermal comfort therefore interacts with other environmental qualities rather than operating as an isolated variable.

User control is particularly relevant in adaptive environments. Operable windows, shaded transitional spaces and adjustable environmental controls can increase occupants' sense of autonomy while allowing them to respond to changing conditions (Tartarini & Schiavon, 2020). This suggests that the proposed gymnasium should incorporate opportunities for localized control where appropriate, while maintaining safe and predictable conditions for patients and high-intensity exercise areas.

The therapeutic perspective also supports a balanced approach to mechanical systems. Air-conditioning can provide useful supplementation, particularly during extreme heat, but the literature and thesis findings both indicate that active systems should work with—not replace—passive design. Integrating ventilation, shading, insulation, landscaping and efficient mechanical cooling can create a more resilient and energy-conscious rehabilitation environment.

III. METHODOLOGY

3.1 Research Design

The study adopted a mixed-method research design combining quantitative and qualitative approaches. Structured questionnaires were used to obtain user perceptions of thermal comfort and architectural features, while field observation, architectural documentation and case-study assessment were used to examine the physical application of thermal strategies. The combined approach allowed the study to consider both user experience and observable building characteristics.

3.2 Study Scope and Area

The study focused on gymnasium spaces within rehabilitation, wellness and fitness facilities in Ibadan, Oyo State, Nigeria. It covered facilities located within Ibadan North, Ibadan North-East, Ibadan North-West, Ibadan South-East, Ibadan South-West, Oluyole, Lagelu and Egbeda. The research concentrated on passive cooling strategies and low-energy mechanical supplements rather than structural, financial or full lifecycle carbon analysis.

3.3 Population, Sampling and Sample Size

The sampling frame comprised 29 registered rehabilitation and wellness centres in Ibadan, including two federal, three state and 24 private facilities. Seven purpose-built centres were purposively selected for detailed study: Oxygen Fitness Akobo, UI Gymnasium, UpJU Fitness, Oyo State Executive Gymnasium, Enoralife Style Spa and Wellness Centre, IITA Gymnasium and Wellness Centre, and Godspeed Fitness Club. Their combined estimated weekly user population was 1,340. Using the thesis sampling procedure, approximately 23% of this population was targeted, giving a study sample of 307 respondents distributed proportionally across the selected facilities.

3.4 Data Collection and Analysis

Primary data were obtained through structured questionnaires, direct observation, architectural drawings and photographs. The questionnaire captured respondents' background characteristics, facility-use patterns, perceptions of thermal comfort and views on architectural and environmental factors. The physical assessment documented ventilation, shading, daylighting, roof and wall conditions, landscaping and other thermal features. Descriptive statistics, frequencies, percentages and average mean values (AMV) were used to summarize the findings, while case-study comparison was used to derive design implications.

IV. FINDINGS AND DISCUSSION

(i) Existing Thermal Comfort Strategies

As seen in Table 1, the facilities demonstrate a strong reliance on relatively simple and familiar thermal strategies. Mechanical fans were the most prevalent feature (91.0%), followed by shading (88.0%), large operable windows (86.0%), daylighting (85.0%), high ceilings (84.0%) and cross-ventilation (81.0%). This pattern suggests that basic airflow and solar-control measures are already embedded in many facilities. However, the lower prevalence of wall insulation, thermal mass, reflective roofing and thermostats indicates that more performance-oriented measures have not been integrated to the same extent. The gap is important because passive design is most effective when individual strategies are coordinated rather than used independently.

Table 1: Thermal Comfort Features Present in the Facilities

S/N	Thermal Comfort Feature	Frequency (Yes)	Percentage (%)	Frequency (No)	Percentage (%)
1	Large operable windows	256	86.0	42	14.0
2	Cross ventilation	241	81.0	57	19.0
3	Courtyard design	185	62.0	133	38.0
4	Shading devices	262	88.0	36	12.0
5	Landscaping	235	79.0	63	21.0
6	High ceiling	250	84.0	48	16.0
7	Roof insulation	173	58.0	125	42.0
8	Wall insulation	146	49.0	152	51.0
9	Mechanical fans	271	91.0	27	9.0
10	Air-conditioning	226	76.0	72	24.0
11	Daylighting	253	85.0	45	15.0
12	Orientation for heat reduction	200	67.0	98	33.0
13	Reflective roofing	161	54.0	137	46.0
14	Thermal mass materials	137	46.0	161	54.0
15	Thermostats	122	41.0	176	59.0

Source: Authors Field work, 2026

(ii) Perceived Effectiveness of Passive and Mechanical Systems

The perceived effectiveness results indicate that the existing thermal strategies are generally viewed positively, but their performance is not uniform. Daylighting and the combination of passive and mechanical systems received the highest ratings (AMV = 4.12), followed by airflow from windows and openings (4.07), shading (4.01), and air-conditioning (4.00). As seen in Table 3, users recognize clear benefits from combining natural and mechanical approaches rather than depending on a single system. The result supports the adaptive and hybrid approach emphasized in the literature (Rupp et al., 2018; Ascione et al., 2021).

The lower ratings reveal where the current systems struggle. Comfort during high humidity received an AMV of 3.50, while comfort during physical activities scored 3.59 and hot-weather comfort 3.64. These results are important because they occur precisely where rehabilitation and fitness users impose higher thermal loads on the environment. The data imply that basic cooling is available, but the systems are less effective under demanding conditions, when metabolic heat and humidity combine to reduce comfort. The lowest AMV, 3.38, concerned the reasonableness of cooling energy consumption, highlighting an operational cost dimension that may limit continued dependence on active cooling.

Table 3: Perceived Effectiveness of Passive and Mechanical Systems in Achieving Thermal Comfort

S/N	Statement	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)	TWV	AMV	Rank
1	Daylighting reduces dependence on artificial lighting	124	126	20	16	12	1228	4.12	1st
2	The combination of passive and mechanical systems provides adequate comfort	126	121	24	15	12	1228	4.12	1st
3	Windows and openings allow sufficient airflow	118	126	24	18	12	1214	4.07	3rd
4	Shading devices reduce indoor heat gain effectively	110	128	26	20	14	1194	4.01	4th
5	Air-conditioning systems maintain comfortable temperatures	112	123	28	20	15	1191	4.00	5th
7.	Natural ventilation provides adequate cooling	102	130	28	22	16	1174	3.94	6th
8.	Landscaping around the building improves thermal comfort	96	130	30	24	18	1156	3.88	7th
6	Ceiling fans provide adequate comfort during occupancy	88	126	34	30	20	1126	3.78	8th
8	Indoor spaces remain comfortable during hot weather	78	119	42	34	25	1085	3.64	9th
9	Thermal comfort is maintained during physical activities	76	115	42	38	27	1069	3.59	10th
10	Indoor spaces remain comfortable during periods of high humidity	72	110	44	40	32	1044	3.50	11th
11	Energy consumption for cooling is reasonable	66	107	40	44	41	1007	3.38	12th

Source: Authors Field work, 2026

(iii) Architectural and Environmental Factors Influencing Thermal Comfort

The results in Table 4 demonstrate that users perceive thermal comfort as being driven first by climatic exposure and then by architectural response. Outdoor temperature recorded the highest AMV (4.34), followed by solar radiation (4.32) and relative humidity (4.28). These three factors indicate that external climatic conditions are strongly transferred into the indoor environment. In a hot-humid city such as Ibadan, the implication is that building design must begin with climatic moderation rather than treating comfort as something to be corrected after construction.

Ventilation design (4.25) and air movement (4.23) were the highest-rated architectural factors, reinforcing the importance of airflow for heat removal. Window size and placement (4.18) also ranked highly, showing that openings are not simply daylighting devices but major components of thermal performance. Vegetation (4.13) and roof design/materials (4.05) further demonstrate that site and envelope strategies contribute materially to comfort. The relatively lower score for wall materials (3.74) does not make them irrelevant; instead, it suggests that wall performance is perceived as somewhat less influential than the dominant climatic and airflow variables.

Table 4: Architectural and Environmental Factors Influencing Thermal Comfort Performance

S/N	Factor	Very High	High	Moderate	Low	Very Low	TWV	AMV	Rank
1	Outdoor temperature	148	123	12	9	6	1292	4.34	1st
2	Solar radiation exposure	146	122	14	10	6	1286	4.32	2nd
3	Relative humidity	142	123	14	11	8	1274	4.28	3rd
4	Ventilation design	138	124	16	12	8	1266	4.25	4th
5	Air movement within spaces	136	123	18	13	8	1260	4.23	5th
6	Window size and placement	130	126	18	14	10	1246	4.18	6th
7	Availability of vegetation and trees	126	124	20	16	12	1230	4.13	7th
8	Roof design and materials	120	121	24	18	15	1207	4.05	8th
9	Occupancy level of spaces	110	119	30	22	17	1177	3.95	9th
10	Building orientation	104	117	36	24	17	1161	3.90	10th
11	Building density around facility	96	119	34	27	22	1134	3.81	11th
12	Wall materials	92	114	40	28	24	1116	3.74	12th

Source: Authors Field work, 2026

(iv) Challenges of Thermal Comfort Management

All identified challenges recorded AMVs above 3.50, showing that respondents regarded each as a meaningful barrier to thermal-comfort management. The most prominent issue was the need for additional passive cooling strategies (4.36), followed by the negative effect of outdoor climatic conditions (4.32) and frequent power outages (4.26). The results in Table 5 indicate that the central problem is not simply inadequate equipment but an incomplete

environmental strategy. Where passive measures are insufficient, facilities become more dependent on mechanical systems, making them more vulnerable to power interruptions and rising operating costs.

The financial and operational context is equally important. Limited funding recorded 4.15, while high energy costs scored 4.08, indicating that even when mechanical systems exist, their effective operation may be constrained by affordability. Building design contributing to overheating (3.99), insufficient air-conditioning (3.91) and poor maintenance (3.83) further show that thermal performance is influenced by the interaction of design quality and facility management. The findings therefore reinforce the case for a low-energy design model in which passive cooling carries a larger share of the thermal load and mechanical systems provide controlled supplementation.

Table 5: Challenges Faced in Maintaining Thermal Comfort

S/N	Challenge	Strongly Agree	Agree	Neutral	Disagree	Disagree	TWV	AMV	Rank
1	The facility requires additional passive cooling strategies	150	124	10	8	6	1298	4.36	1st
2	Outdoor climatic conditions negatively affect indoor comfort	146	122	14	10	6	1286	4.32	2nd
3.	Frequent power outages affect thermal comfort	140	122	16	12	8	1268	4.26	3rd
4.	Limited funding affects thermal comfort improvements	130	123	18	15	12	1238	4.15	4th
5.	High energy costs limit cooling operations	124	120	22	18	14	1216	4.08	5th
6.	Building design contributes to overheating	116	119	24	21	18	1188	3.99	6th
7.	Air-conditioning systems are insufficient	110	116	28	24	20	1166	3.91	7th
8	Maintenance of cooling equipment is inadequate	102	116	30	28	22	1142	3.83	8th
9.	Existing ventilation systems are inadequate	98	114	32	30	24	1126	3.78	9th
10.	High occupancy levels reduce thermal comfort	94	109	34	34	27	1103	3.70	10th

Source: Authors Field work, 2026

V. CONCLUSION

The selected rehabilitation, wellness and gymnasium facilities rely mainly on basic thermal strategies, especially mechanical fans, shading devices, operable windows, daylighting, high ceilings and cross-ventilation. More advanced measures such as wall insulation, thermal-mass materials, reflective roofing and thermostatic control were less prevalent. The study therefore concludes that the facilities possess a foundational passive and mechanical infrastructure, but that the level of integration remains limited.

The combined passive and mechanical systems were generally perceived as effective, with the strongest ratings recorded for daylighting and integrated passive-mechanical systems. However, the lower ratings for high-humidity conditions, physical activity and cooling-energy reasonableness demonstrate that performance declines under demanding conditions. Thermal comfort is therefore adequate in general terms but not uniformly resilient to climatic and operational stress.

Outdoor temperature, solar radiation, humidity, ventilation design, air movement, window configuration and vegetation are the main factors influencing thermal comfort. The research further established that additional passive cooling, adverse outdoor conditions, power outages, funding limitations, high energy costs, overheating from building design and maintenance deficiencies are major constraints.

Recommendations

The proposed gymnasium should move beyond isolated thermal features and adopt an integrated passive-design strategy. Cross-ventilation, operable windows, high-level openings, shading, landscaping, appropriate orientation and climate-responsive roof design should be coordinated from the conceptual stage rather than added individually after the layout has been established.

Mechanical systems should complement passive strategies through energy-efficient fans and air-conditioning, smart controls and regular commissioning. The design should allow mechanical systems to operate only when passive measures cannot maintain acceptable conditions, thereby reducing unnecessary energy consumption while retaining thermal reliability during peak heat conditions.

The building envelope should respond directly to the dominant factors identified by respondents. Orientation should minimize problematic solar exposure, windows should be sized and positioned to support cross-ventilation, roof materials should reduce heat gain, and vegetation should be strategically located to shade external surfaces and transitional spaces. Thermal zoning should also differentiate high-intensity exercise areas from rehabilitation and recovery spaces with different comfort demands.

The project should incorporate resilience measures that address power outages, maintenance and energy cost. Solar photovoltaic systems, inverters and appropriate backup generation can protect essential environmental systems during grid failure. Cooling equipment should be selected for efficiency, maintained regularly and supported by energy audits and smart controls. Funding and regulatory stakeholders should also be encouraged to develop performance standards for rehabilitation and wellness facilities.

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