KEMENTERIAN PENDIDIKAN, KEBUDAYAAN, RISET, DAN TEKNOLOGI
UNIVERSITAS DIPONEGORO
LEMBAGA PENELITIAN DAN PENGABDIAN KEPADA MASYARAKAT

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SURAT PENUGASAN PELAKSANAAN KEGIATAN BATCH II
RISET PUBLIKASI INTERNASIONAL (RPI)
DIBIAYAI SELAIN ANGGARAN PENDAPATAN DAN BELANJA NEGARA (SELAIN APBN)
UNIVERSITAS DIPONEGORO TAHUN ANGGARAN 2022

Nomor : 569-152/UN7.D2/PP/VII/2022

Pada hari ini SELASA tanggal DUA PULUH ENAM bulan JULI tahun DUA RIBU DUA PULUH DUA kami yang bertanda tangan di bawah ini:

1. Prof. Dr. Jamari, S.T., M.T. : Ketua Lembaga Penelitian dan Pengabdian kepada Masyarakat Universitas Diponegoro berkedudukan di Kota Semarang, berdasarkan SK Rektor Universitas Diponegoro Nomor: 561/UN7.P/KP/2019 tanggal 2 Agustus 2019 tentang pengangkatan Ketua Lembaga Penelitian dan Pengabdian kepada Masyarakat Universitas Diponegoro periode masa jabatan 2019-2022, untuk selanjutnya disebut PIHAK PERTAMA.

2. Dr. Ir Heru Prastawa, DEA : Dosen Fakultas Teknik Universitas Diponegoro, dalam hal ini bertindak sebagai Ketua Pelaksana Riset Publikasi Internasional (RPI) Tahun Anggaran 2022 yang selanjutnya disebut PIHAK KEDUA.

Berdasarkan Surat Keputusan Rektor Universitas Diponegoro nomor: 215/UN7.A/HK/VII/2022 tanggal 25 Juli 2022, tentang Penetapan Pendanaan Kegiatan Riset dan Pengabdian kepada Masyarakat Universitas Diponegoro Batch II Tahun 2022 yang di biayai Selain Anggaran Pendapatan dan Belanja Negara (APBN) Tahun Anggaran 2022, PIHAK PERTAMA dan PIHAK KEDUA, secara bersama-sama sepakat mengikatkan diri dalam suatu Penugasan Pelaksanaan Kegiatan Riset dengan ketentuan dan syarat-syarat sebagaimana diatur dalam pasal-pasal sebagai berikut:

Pasal 1
Pelaksanaan Penugasan

(1) PIHAK PERTAMA menugaskan kepada PIHAK KEDUA untuk melaksanakan Riset tahun ke 1 dari rencana 2 tahun dengan Tim Riset dan Judul Riset sebagai berikut:
- Tim Riset : 1. Dr. Ir Heru Prastawa, DEA
  2. Wiwik Budiawan, S.T., M.T., Ph.D.
- Judul Riset : Adaptive thermal comfort of university students with energy-saving potential in the university dormitories during dry and wet seasons in Indonesia

(2) PIHAK PERTAMA menyerahkan dana riset sebagaimana dimaksud pada ayat (1) sebesar Rp. 60.000.000,00 (*Enam puluh juta rupiah*) yang berasal dari Selain Anggaran Pendapatan dan Belanja Negara (Selain APBN) Universitas Diponegoro Tahun Anggaran 2022;

(3) PIHAK KEDUA bertanggung jawab penuh atas pelaksanaan riset, pengadministrasian, pembelanjaan, dan pelaporan keuangan sebagaimana dimaksud pada ayat (1) sesuai dengan ketentuan yang berlaku;

(4) PIHAK KEDUA berkewajiban mengembalikan sisa dana riset yang tidak dibelanjakan ke Bendahara Penerimaan Universitas Diponegoro melalui PIHAK PERTAMA;

(5) Apabila PIHAK KEDUA tidak dapat melaksanakan riset sebagaimana dimaksud pada ayat (1) maka PIHAK KEDUA wajib mengembalikan dana sebagaimana disebutkan pada ayat (2) ke Bendahara Universitas Diponegoro melalui PIHAK PERTAMA.

Pasal 2
Cara Pembayaran dan Mekanisme Pencairan Dana Riset

(1) Dana riset sebagaimana dimaksud dalam pasal 1 ayat (2) dibayarkan melalui rekening atas nama PIHAK KEDUA pada bank yang ditunjuk oleh PIHAK PERTAMA;

(2) PIHAK PERTAMA akan membayarkan dana riset kepada PIHAK KEDUA secara bertahap dengan ketentuan sebagai berikut:

   a. Pembayaran tahap pertama sebesar 70% dari total dana riset yaitu 70% x Rp. 60.000.000,00 = Rp. 42.000.000,00 (*Empat puluh dua juta rupiah*) setelah PIHAK KEDUA menandatangani dan mengunggah Surat Pelaksanaan Penugasan (SPK) maupun mengunggah proposal pelaksanaan di laman SIP3MU;

   b. Pembayaran tahap kedua sebesar 30% dari total dana riset yaitu 30% x Rp. 60.000.000,00 = Rp. 18.000.000,00 (*Delapan belas juta rupiah*) setelah PIHAK KEDUA mengunggah seluruh laporan sesuai dengan ketentuan yang berlaku ke laman SIP3MU.

Pasal 3
Pemblokiran Dana Riset

(1) PIHAK KEDUA memberikan kuasa penuh kepada PIHAK PERTAMA untuk melakukan blokir saldo sejumlah dana yang telah dibayarkan oleh PIHAK PERTAMA kepada PIHAK KEDUA apabila PIHAK KEDUA belum memenuhi segala kewajiban dan persyaratan pancairan;

(2) PIHAK PERTAMA tidak melakukan pemblokiran dana riset tahap pertama (70%) yang telah ditransfer kepada PIHAK KEDUA;

(3) PIHAK PERTAMA melakukan pemblokiran dana riset tahap kedua (30%) yang telah ditransfer kepada PIHAK KEDUA;

(4) Pembukaan blokir sebagaimana disebut pada ayat (3) dilakukan setelah PIHAK KEDUA menyelesaikan seluruh kewajibannya.

Pasal 4
Jangka Waktu Pelaksanaan Riset

Surat Penugasan Pelaksanaan Kegiatan Riset ini berlaku dari tanggal 11 Juli 2022 sampai dengan 15 Desember 2022.

Pasal 5
Monitoring dan Evaluasi Riset

(1) PIHAK PERTAMA berhak melakukan monitoring dan evaluasi terhadap pelaksanaan riset yang dilakukan oleh PIHAK KEDUA.

(2) PIHAK KEDUA wajib mengikuti monitoring dan evaluasi riset yang dilakukan oleh PIHAK PERTAMA dengan persyaratan mengunggah Laporan Kemajuan dan Buku Catatan Hasil Riset pada laman SIP3MU LPPM Universitas Diponegoro serta menyerahkan Laporan Penggunaan Dana Riset tahap pertama sebesar 70% minimal dalam bentuk draft selambat-lambatnya 1 (satu) minggu sebelum pelaksanaan monitoring dan evaluasi.

Pasal 6
Luaran Riset

(1) PIHAK KEDUA berkewajiban memenuhi luaran yang telah ditetapkan dalam proposal riset, sesuai dengan Buku Panduan Pelaksanaan Penelitian dan Pengabdian kepada Masyarakat Universitas Diponegoro yang berlaku;

(2) Batas waktu pencapaian luaran sebagaimana dimaksud pada ayat (1) dapat dicapai selama 6 (enam) bulan setelah kontrak selesai. Dan apabila belum tercapai dapat diberi tambahan waktu selama 6 (enam) bulan lagi atau lebih berdasarkan hasil evaluasi oleh *reviewer*;

(3) Hak kepemilikan luaran riset sebagaimana dimaksud pada ayat (1) adalah milik Universitas Diponegoro dan dikelola sesuai dengan kententuan yang berlaku.

Pasal 7
Pelaporan Riset

(1) PIHAK KEDUA berkewajiban mengunggah ke laman SIP3MU LPPM Universitas Diponegoro antara lain: Surat pelaksanaan Penugasan Kegiatan (SPK), Proposal Pelaksanaan, Buku Catatan Hasil Riset, Laporan Kemajuan Riset, Laporan Akhir Riset, Luaran Riset, Poster (bagi riset tahun terakhir) dan menyerahkan Laporan Penggunaan Dana Riset tahap pertama sebesar 70% maupun tahap kedua sebesar 30% dijilid menjadi 1 (satu) dan dibuat rangkap 2 (dua), asli diserahkan kepada PIHAK PERTAMA serta *copy* sebagai arsip PIHAK KEDUA;

(2) Batas waktu kewajiban penyerahan Laporan Penggunaan Dana Riset maupun unggah laporan-laporan riset ke laman SIP3MU Undip seperti termaktub pada ayat (1), paling lambat tanggal 15 Desember 2022.

(3) Bilamana diperlukan PIHAK PERTAMA dapat meminta kepada PIHAK KEDUA untuk menyerahkan dokumen hasil unggahan sebagaimana tersebut pada ayat (1) dalam bentuk *hardcopy* dengan persyaratan sebagai berikut:

a. Laporan diketik dengan huruf times new roman ukuran 12, spasi 1,5;
b. Ukuran kertas kwarto A4;
c. Warna cover dijilid sesuai dengan skema riset yang ada di buku panduan yang berlaku;
d. *Hardcopy* laporan dijilid dalam bentuk *soft cover laminating*;
e. Di bagian bawah cover ditulis:

Dibiayai Selain Anggaran Pendapatan dan Belanja Negara (Selain APBN) Universitas Diponegoro Tahun Anggaran 2022 Keputusan Rektor Universitas Diponegoro Nomor : 215/UN7.A/HK/VII/2022 No SPK : 569-152/UN7.D2/PP/VII/2022

Pasal 8
Perubahan Susunan Tim Pelaksana Riset

Perubahan terhadap susunan tim pelaksana riset dapat dibenarkan apabila telah mendapat persetujuan tertulis dari Ketua Lembaga Penelitian dan Pengabdian kepada Masyarakat Universitas Diponegoro.

Pasal 9

Pajak dan Meterai

(1) PIHAK KEDUA berkewajiban membayar pajak sesuai dengan ketentuan yang berlaku;

(2) Tata cara pembayaran pajak diatur oleh PIHAK PERTAMA dalam Panduan Pertanggungjawaban Keuangan Penelitian dan Pengabdian Kepada Masyarakat;

(3) Biaya Materai dalam surat penugasan ini dibebankan kepada PIHAK KEDUA.

Pasal 10

Kepemilikan Hasil Riset

(1) Hak Kekayaan Intelektual (HKI)/Paten yang dihasilkan dari pelaksanaan riset menjadi milik Universitas Diponegoro, diatur dan dikelola sesuai dengan peraturan yang berlaku;

(2) Setiap publikasi, makalah, dan/atau ekspos dalam bentuk apapun yang berkaitan dengan hasil riset ini wajib mencantumkan nama Universitas Diponegoro sebagai pemberi dana pelaksanaan riset.

(3) Bilamana pelaksanaan riset ini menghasilkan aset tetap maka PIHAK KEDUA berkewajiban menyerahkan kepada PIHAK PERTAMA yang dilampiri berita acara serah terima dengan ketentuan sebagai berikut:

   a. Aset tetap tersebut telah terdaftar dalam registrasi pengelolaan barang milik Negara;

   b. Aset tetap tersebut dilampiri dengan Standar Operasional Prosedur (SOP).

(4) Hasil riset yang berupa aset tetap dari kegiatan ini dicatat secara tertib dan akuntabel dalam inventaris fakultas homebase ketua riset dan menjadi aset Universitas Diponegoro.

Pasal 11

Pelanggaran Kode Etik Ilmiah

(1) Pengusulan dan Pelaksanaan Riset harus berdasarkan kode etik ilmiah;

(2) Apabila dikemudian hari ternyata judul riset sebagaimana dimaksud pada pasal 1 ditemukan adanya pelanggaran kode etik ilmiah, maka kegiatan riset tersebut dinyatakan batal dan PIHAK KEDUA wajib mengembalikan dana riset yang telah diterima ke bendahara penerima Universitas Diponegoro melalui PIHAK PERTAMA.

Pasal 12

Sanksi/Denda

(1) Apabila sampai dengan batas waktu yang telah ditentukan, PIHAK KEDUA belum memenuhi kewajibannya maka dapat dikenakan sanksi oleh PIHAK PERTAMA;

(2) Apabila PIHAK KEDUA belum dapat menyelesaikan pekerjaan berdasarkan jangka waktu yang telah ditetapkan dalam surat penugasan ini, maka dapat dikenakan denda oleh PIHAK PERTAMA;

(3) Dalam memberikan/tidak memberikan sanksi/denda PIHAK PERTAMA memperhatikan hasil evaluasi *reviewer*.

Pasal 13
Penyelesaian Perselisihan

Apabila terjadi perselisihan antara PIHAK PERTAMA dan PIHAK KEDUA dalam Surat Penugasan Pelaksanaan Kegiatan Riset ini, akan dilakukan penyelesaian secara musyawarah dan mufakat, sekiranya tidak tercapai penyelesaian secara musyawarah dan mufakat maka penyelesaian dilakukan melalui proses hukum dengan memilih tempat di Pengadilan Negeri Semarang, sebagai upaya hukum tingkat pertama dan terakhir.

Pasal 14
Keadaan Memaksa (*force majeure*)

(1) PARA PIHAK dibebaskan dari tanggung jawab atas keterlambatan atau kegagalan dalam memenuhi kewajiban yang dimaksud dalam Penugasan Pelaksanaan Riset yang disebabkan atau diakibatkan oleh peristiwa diluar kekuasaan PARA PIHAK yang dapat digolongkan sebagai keadaan memaksa (*force majeure*);

(2) Peristiwa atau kejadian yang dapat digolongkan keadaan memaksa (*force majeure*) dalam Penugasan Pelaksanaan Riset ini antara lain: bencana alam, wabah penyakit, kebakaran, perang, blokade, peledakan, sabotase, revolusi, pemberontakan, huru-hara, serta adanya tindakan pemerintah dalam bidang ekonomi dan moneter yang secara nyata berpengaruh terhadap Penugasan Pelaksanaan Riset ini;

(3) Apabila terjadi keadaan memaksa (*force majeure*) maka pihak yang mengalami wajib memberitahukan kepada pihak lainnya secara tertulis, selambat-lambatnya dalam waktu 7(tujuh) hari kerja sejak terjadinya keadaan memaksa (*force majeure*) disertai bukti-bukti yang sah dari pihak yang berwajib, dan PARA PIHAK dengan itikad baik akan segera membicarakan penyelesaiannya.

Pasal 15
Adendum dan Penutup

(1) Hal-hal yang belum diatur dalam Surat Penugasan Pelaksanaan Kegiatan Riset ini diatur kemudian antara PIHAK PERTAMA dan PIHAK KEDUA yang akan dituangkan dalam bentuk adendum dan merupakan bagian tak terpisahkan dari Surat Penugasan ini;
(2) Surat Penugasan Pelaksanaan Kegiatan Riset ini dibuat rangkap 2 (dua) dan bermaterai cukup sesuai dengan ketentuan yang berlaku.

PIHAK KEDUA	PIHAK PERTAMA
Dr. Ir Heru Prastawa, DEA	Prof. Dr. Jamari, S.T., M.T.
NIDN 0015036004	NIP 197403042000121001

LAPORAN ANKHIR PENELITIAN / ~~PENGABDIAN KEPADA MASYARAKATUNIVERSITAS DIPONEGORO~~

Petunjuk:Pengusul hanya diperkenankan mengisi di tempat yang telah disediakan sesuai dengan petunjuk pengisian.

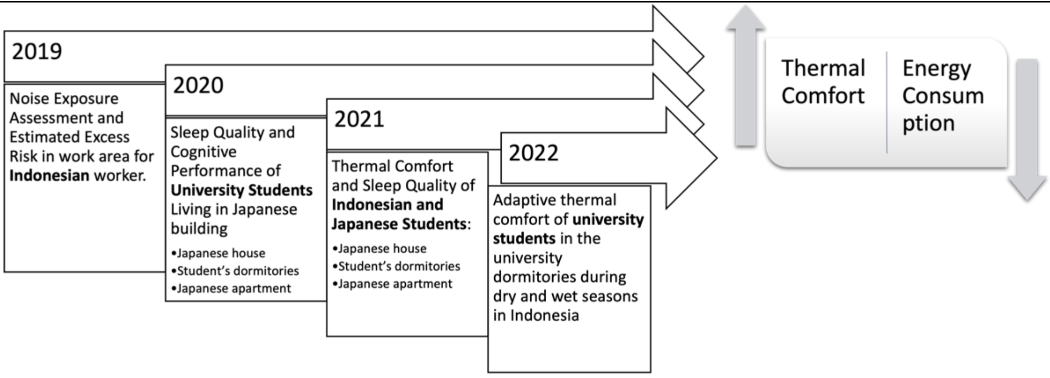
Skema Hibah

Riset Publikasi Internasional (RPI)

Judul (*Title*)

Adaptive thermal comfort of university students with energy-saving potential in the university dormitories during dry andwet seasons in Indonesia

Keterkaitan penelitian/pengabdian kepada masyarakat lain (*Linkages*)
(Maksimum 50 kata)



ABSTRAK(*Abstract*)

(Maksimum 200 kata)

Environmental is one of big problems in the world today. One of the main causes of the complicated environmental problems is the use of too much energy on a global level. The effective local measure to save energy and use it more efficiently can be part of the solution. One way to cut down on energy use is to use adaptive thermal comfort. Building occupants who can control and connect with their immediate thermal environment, and who can adapt to that environment, use less energy over time. Comfort is hard to achieve since it is the result of a complex system that includes the person, the building, the indoor microclimate, and even the outside climate.

The current study is exploring into how university students in dormitories in Semarang, Indonesia, and what they think about their indoor environment. As a first step, we want to investigate what temperature ranges are comfortable for people from Semarang and other places. We also want to figure out how tolerant the people who live there are of their surroundings. Non-Semarang

students and students from Semarang were expected to have different comfort temperatures in the dry and wet seasons.

Kata Kunci (*Keywords*)
Cantumkan maksimal 5 kata kunci yang digunakan.

Thermal comfort, Indonesia, University dormitories, Energy

PENDAHULUAN (*Introduction*)

Uraikan latar belakang masalah yang akan diselesaikan dan tujuan penelitian. Pada Proposal pengabdian kepada masyarakat: (jelaskan profile, potensi dan urgensi kebutuhan mitra serta potensi hilirisasi riset yang akan diaplikasikan secara sinergi melalui pemberdayaan mitra/masyarakat (maksimum 500 kata). Sitasi menggunakan format *Vancouver* dengan *superscript numbers,* atau *standard numbers* dalam *brackets* di text, contoh. [1-4,10,12] atau [1-4,10,12]

Since developing the adaptive concept, thermal comfort has been investigated in traditional houses in Nepal [1], in contemporary houses in the United Kingdom [2], Singapore [3], Indonesia [4], Malaysia [5], India [6], China [7], [8], Japan [9] and throughout the world in a variety of building types. The importance of rethinking comfort has been widely acknowledged. Subjective comfort was demonstrated to be achievable in a much broader range of conditions than previously believed, and while this presents challenges for building design, it also holds significant potential for energy conservation.

Today's environmental difficulties are complicated, and energy consumption is a significant contributor to the problems, but it is still only a part of the problem. Adaptive thermal comfort is one technique to handle the multifaceted issue of energy consumption. Allowing buildings to reconnect with their immediate thermal environment in order to adapt to it has an effect on the buildings' energy consumption. However, subjective comfort is influenced by the type of building and its occupancy.

Due to their previously unexplored status, dormitory buildings have sparked renewed research interest in China in recent years, resulting in field studies conducted throughout the year [10], [11], [12], [13], [14]. Personal control was less restricted in dormitories, which stimulated a diverse range of adaptive behaviors and, consequently, a diverse range of comfort levels.

In the previous study, Schweiker and Shukuya focused their research on changing occupants' behavioral patterns in dormitories. They discovered that in moderate climates, it can result in a significant reduction in a building's energy consumption. When combined with improvements to the building's envelope, overall energy consumption can be reduced by 76–95 percent [15]. They also experimented with the most effective methods for changing behavioral patterns toward the use of low-energy measures to achieve comfort. Their research demonstrated that personally disseminating information in the form of a workshop can result in effective behavioral change and a subsequent reduction of up to 16% in the use of cooling devices [16], as well as altering occupant window interaction [17], both of which can result in potential energy conservation.

Maslow's theory about what a built environment should provide puts comfort at the top [18]. It is probably similar to the self-actualization level, level 5, which is the highest level of human needs. Humphreys, one of several researchers in the field of adaptive comfort, wrote in his book on the foundations and analysis of adaptive thermal comfort that the comfort solution is a whole system that includes the behavior, the type of buildings, and the indoor microclimate.

We planned and conducted a field survey in two university dormitory buildings. We sought to capture the students' thermal comfort in relation to temperature and humidity, as well as to other variables such as the time of day, the use or non-use of air conditioning (CL – cooling mode and FR – free running mode, respectively), the occupied building, sex, and – most importantly – the origin of occupants. We wanted to determine which sensations occupants prefer and how to decrease the energy consumption.

RASIONAL DAN SIGNIFIKANSI PENELITIAN / PENGABDIAN KEPADA MASYARAKAT (***Novelty***).

Penelitian: jelaskan relevansi rasional, signifikansi, potensi dan peluang hasil penelitian untuk publikasi sesuai target luaran yang diwajibkan.

Pengabdian kepada masyarakat:

- Jelaskan relevansi dan potensi aplikasi IPTEK/rekayasa sosial/ekonomi/hilirisasi riset dalam menyelesaikan permasalahan mitra.
- Jelaskan dampak kegiatan pengabdian kepada masyarakat tersebut dalam meningkatkan kapabilitas/potensi mitra sesuai luaran.
(maksimum 500 kata).

In Semarang Indonesia, dormitories and apartments near university will keep increasing the number of their non-Semarang or non-Indonesian occupants relative to Diponegoro University's aim of globalizations of university. However, dormitories and apartments can never be as flexible as necessary to accommodate the ever-changing residents.

Managing the adaptability that the adaptive approach necessitates is the primary obstacle driving study in the topic. How can a designer create a building that can accommodate the needs of any occupant if the needs of each occupant are unique? How can an engineer give every required piece of equipment or standard? Which and how much equipment is required for this issue?

These concerns become even more pertinent in structures with frequently changing residents, i.e., buildings for temporary tenancy (one semester or one year), such as dormitories, that cannot be exactly suited to specific occupants. In a globalized world, it is more usual for students to study abroad and be exposed to new cultural and climatic situations while retaining their original expectations and practices. The phenomena is widespread at the Diponegoro University. Existing and freshly planned buildings for multi-cultural habitation face the challenge of accommodating a variety of subjective comfort standards while maintaining energy efficiency. To address the problem, it is vital to know what comfort in terms of temperature range means to non-Semarang residents and what the disparities are.

TARGET LUARAN PENELITIAN / PENGABDIAN KEPADA MASYARAKAT (*Target*).

Jelaskan target-target luaran yang akan dihasilkan dalam penelitian atau pengabdian kepada masyarakat selama periode tahun yang diusulkan (maksimum 100 kata).

The information of field survey (thermal comfort, indoor environment, energy condumption, and subjective preferences) is used to study the standard. This results and comparison between Semarang and Non-Semarang people will be published in the **Energy and Building Journal** (Q1).

DESAIN / METODE PENELITIAN / PENGABDIAN KEPADA MASYARAKAT (*Method*).

1. Penelitian: jelaskan metode yang direncanakan sesuai dengan penyelesaian tujuan, tahapan, dan hubungannya dengan topik luaran yang ditargetkan dari setiap tahapan penelitian.
2. Pengabdian kepada masyarakat: dapat dilengkapi dengan gambaran IPTEK/hilirisasi riset yang akan diaplikasikan. (maksimum 500 kata).

The field survey was designed and carried out throughout the dry and wet seasons of 2022 in two university dormitories. The objectives were: 1) to compare the subjective thermal comfort of Semarang and non-Semarang students in relation to temperature, humidity, and other factors; 2) to determine if there is a difference between the temperature defined as neutral and comfortable; and 3) to gain an understanding of the students' tolerance to their indoor environment.

Semarang is situated on Java's northern shore. Semarang City's elevation ranges from 2 meters (6.6 feet) below sea level to 340 meters (1,120 feet) above sea level, with a slope of 0% to 45%. Semarang City has a distinctive topographic condition consisting of a limited lowland area and steep areas running from the city's west side to its east side. The subtype of climate described by the Köppen Climate Classification is "Am" (Climate of tropical monsoons). Semarang has an annual average temperature of 83°F (28.3°C). April, with an average temperature of 84.0°F (28.9°C), is the month with the highest average temperature. January, with an average temperature of 81.0°F (27.2°C), is the month with the lowest average temperature. In July, Semarang reached a maximum temperature of 106.0 °F (41.1 °C). July in Semarang saw the lowest temperature of 64.0°F (17.8°C). The annual average precipitation in Semarang is 109.5 inches (2781.3 mm). January has an average of 17.3" (439.4 mm) of precipitation, making it the wettest month. August, with an average of 2.4" of precipitation, is the month with the lowest average precipitation (61 mm).

The field survey was intended to be longitudinal (repeated sampling of limited number of subjects). In most cases, the time interval between each response to a topic was greater than 3 to 4 hours, and sometimes as much as 6 to 10 hours. The data were examined as a cross-sectional study because to the significant time gap between responses (singular sampling of many subjects).

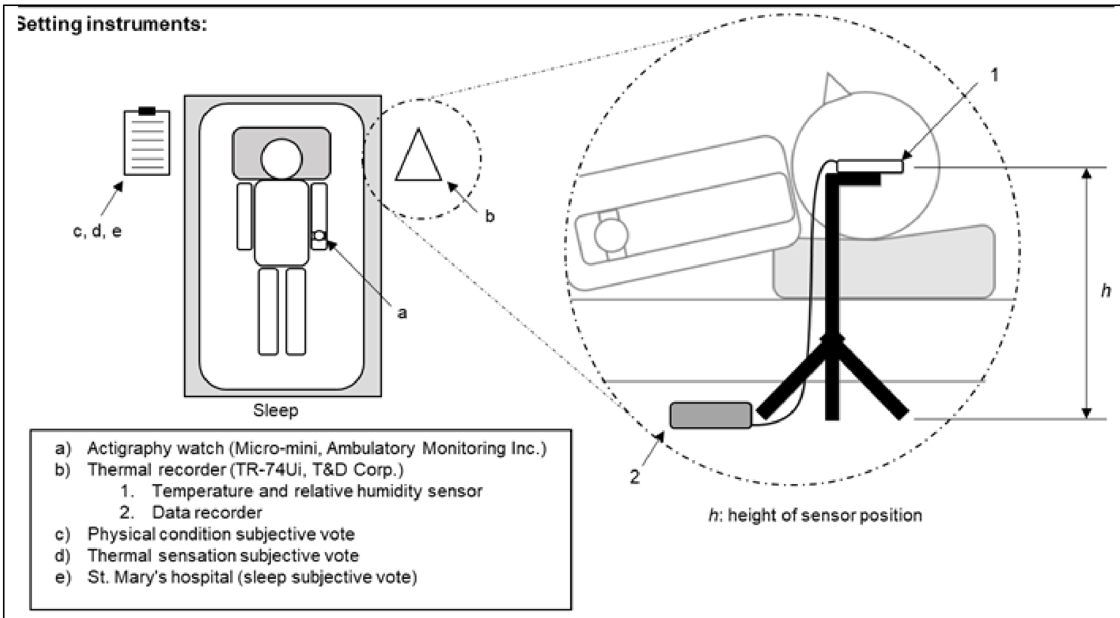
Day	Morning	Noon	Evening
Monday			1, 2, 3
Tuesday	3, 4, 3*	3*	3*, 3
Wednesday	3, 4, 3*	3*	3*, 3
Thursday	3, 4, 3*	3*	3*, 3
Friday	3, 4, 5		

- 1 Setting the instruments in participants' rooms
- 2 General health questionnaire (filled in only on the first Monday)
- 3 Indoor environment questionnaire
- 3* Optional if at home (at breakfast, at lunch, at dinner time)
- 4 Sleep quality questionnaire (about previous night)
- 5 Collecting measuring instruments from participants' rooms

The subjective thermal votes were gathered using the suggested scales and question wording from ISO 10551: 1995 I for assessment of thermal environment using subjective judging scales and the ASHRAE 2013 handbook. These were the relevant questions: TSV (thermal sensation vote): "How do you feel about the thermal environment in your room at this exact moment?" TC (thermal comfort/evaluation vote): "How do you feel about the temperature in your room?" TP (thermal preference vote): "Please indicate how you would want to be at this moment." TA (thermal acceptability vote): "How do you assess the thermal environment?”

Name	Type	Parameter	Range and accuracy
Thermo-hygrometer	TR-74Ui ISA-3151 sensor THA-3151 sensor	Air temperature Relative humidity Illuminance	0-55 °C (±0.5°C) 10-95 %RH (±5%) 0-130klx (±5%)
Air Flow Transducer	6332D (KANOMAX probe) (VR-71 data logger)	Air Speed	0.01~30.0m/s (±2%)

Monday through Friday, the indoor and outdoor air temperature and relative humidity were continuously measured at one-minute intervals. The measuring devices were set at desk height in each individual room, assuming sedentary activity. In the living area, the data loggers were positioned between 0.6 and 1.1 meters above the floor. Air velocity was observed near the bed.



The data obtained was examined using Microsoft Excel and the add-in tool Data Analysis, as well as the add-in program XLstat (Addinsoft Inc., New York, USA).

Results

In the current study, 68 healthy university students from 20 to 35 years of age participated in this study. The survey measured and obtained data for a total of 192 days. The 36 participants were Indonesian students (28.9 ± 3.9 years of age, 24.6 ± 4.0 kg/m^2 of body mass index), whereas 32 participants were Japanese students (22.9 ± 0.5 years of age, 20.7 ± 2.1 kg/m^2 of body mass index). This survey imposed no restrictions on the indoor environment, daytime activities, meals, clothing, or bathing time, and only required participants to sleep in their own bedrooms.

In the winter, the average of indoor air temperature and relative humidity were significant different between Indonesian and Japanese students. The results of the investigation of the thermal environment in two seasons and two nationalities' bedrooms during sleep are summarized in Table 2. The total of sample point was 192. In the current study, sunrise was at 05:07 ± 19 min in summer and 06:27 ± 25 min in winter. Sunset was at 18:27 ± 28 min in summer and 17:25 ± 24 min in winter. The daylight hours were longer in summer (13 h 19 min ± 47 min) than in the winter (10 h 57 min ± 49 min).

In addition, the temperature and relative humidity of the indoor air were categorized into 1°C and 10% bins, respectively. *Figure 1* depicts the frequency distribution of indoor air temperature inside each bin. During the summer, the indoor air temperature that occurred most frequently was between 26 and 28 degrees Celsius for Indonesian and Japanese students. During the winter, the indoor air temperature was 20 °C for Indonesian and Japanese students and 21 °C for Indonesian students. *Figure 2* depicts the frequency distribution of indoor relative humidity. The minimum indoor relative humidity was same for Indonesian and Japanese students during summer (35% of RH) and during winter (25% of RH).

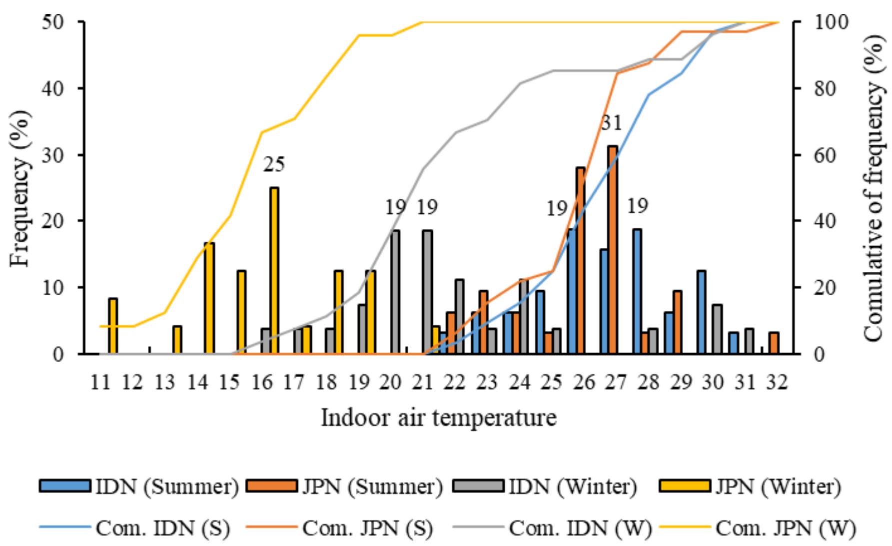


Figure 1 Frequency distribution of indoor air temperature; Abbreviation: IDN, Indonesian; JPN, Japanese; Com., cumulative; S, summer; W, winter.

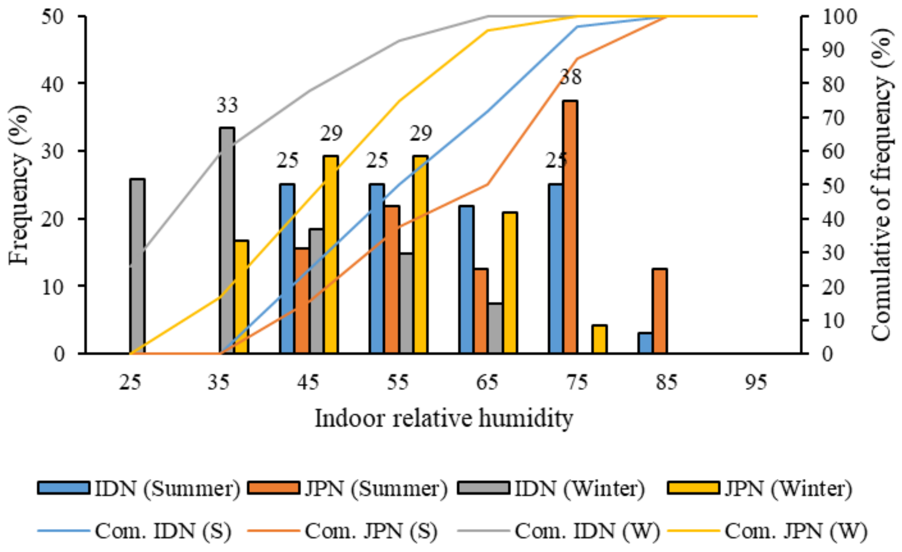


Figure 2 Frequency distribution of indoor relative humidity; Abbreviation: IDN, Indonesian; JPN, Japanese; Com., cumulative; S, summer; W, winter.

In the summer, Indonesian students awoke at an average time of 5:49 a.m., while Japanese students awoke at an average time of 8:59 a.m. In the winter, on average, Indonesian students awoke at 5:53 a.m., while Japanese students awoke at 8:41 a.m. In the summer, 21.9 % of Indonesian students and 34.4 % of Japanese students napped during the day. In the winter, 16.7 % of Indonesian students and 12.5 % of Japanese students napped. Indonesian students went to bed at 23:49 (95 min) and woke up at 05:50 (108 min) and Japanese students went to bed at 01:20 (74 min) and woke up at 08:42 (39 min) during summer. In winter, Indonesian students went to bed at 23:30 (111 min) and woke up at 06:15 (76 min), and Japanese students went to bed at 01:19 (73 min) and woke up at 08:28 (73 min).

Based on actigraphy data, Table below presents the average of sleep quality metrics (duration on bed, sleep length, sleep rate, sleep efficiency, and sleep latency).

Parameters	IDN (S)	JPN (S)	IDN (W)	JPN (W)
Duration on bed (min)	361.9 ± 62.1	442.2 ± 60.5	406.1 ± 89.7	429.8 ± 102.3
Sleep duration (min)	311.5 ± 72.9	370.9 ± 62.7	338.3 ± 93.8	380.3 ± 99.4
Sleep rate (%)	85.6 ± 10.3	84.6 ± 13.3	82.7 ± 11.7	88.4 ± 8.2
Sleep efficiency (%)	92.4 ± 8.5	91.1 ± 11.6	88.5 ± 9.1	94.5 ± 5.9
Sleep latency (min)	25.4 ± 24.7	28.8 ± 26.4	24.7 ± 31.4	9.3 ± 15.0

We also analyzed sleep sensation (sleep depth, wellness, and clear-headed in the morning) using the St. Mary's Hospital (SMH) questionnaire and measured bedroom temperature 15 minutes after waking up.

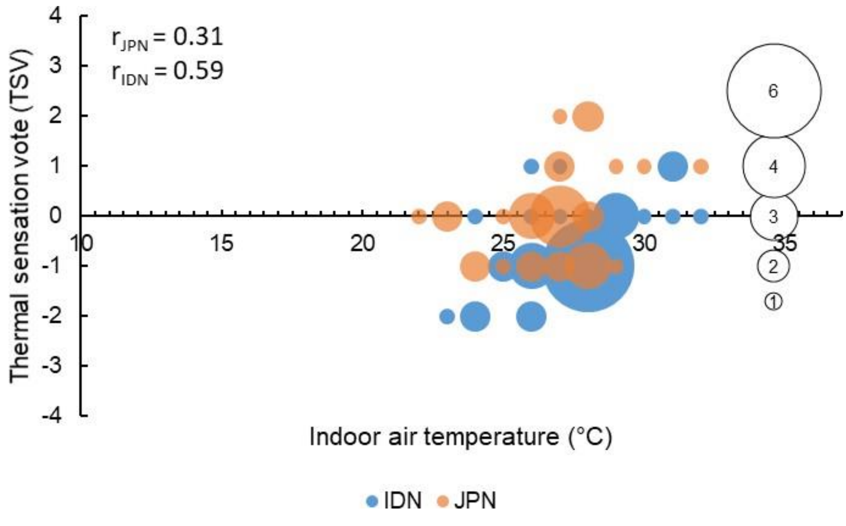
Parameters	IDN	JPN	IDN	JPN
Sleep-depth (1 to 8)	5.3 ± 1.2	4.5 ± 1.6	5.0 ± 1.2	4.9 ± 1.5
Wellness (1 to 6)	4.2 ± 0.7	3.6 ± 1.1	4.5 ± 0.6	4.1 ± 0.9
Clear-headedness (1 to 6)	3.9 ± 0.5	2.0 ± 0.6	3.5 ± 0.8	2.3 ± 0.9

Table below presents the comfort temperature of participants.

Scale	Thermal sensation					Thermal comfort				
	Scale word	Summer		Winter		Scale word	Summer		Winter	
		IDN	JPN	IDN	JPN		IDN	JPN	IDN	JPN
3	Hot	0%	0%	0%	0%	Very comfortable	0%	3%	7%	13%
2	Warm	0%	9%	4%	0%	Comfortable	16%	31%	11%	21%
1	Slightly warm	13%	16%	11%	29%	Slightly comfortable	47%	38%	19%	38%
0	Neutral	31%	41%	33%	50%	Neutral	25%	6%	26%	17%
-1	Slightly cool	41%	34%	33%	13%	Slightly uncomfortable	9%	19%	26%	8%
-2	Cool	16%	0%	7%	4%	Uncomfortable	3%	0%	7%	4%
-3	Cold	0%	0%	11%	4%	Very uncomfortable	0%	3%	4%	0%

we examined the relationship between the two subjective sensations mentioned previously and the indoor air temperature. To calculate the frequency of correlation between physical and subjective measurements, the indoor air temperature was rounded to one degree Celsius. Figure below illustrates the frequency and correlation between indoor air temperature, thermal sensation vote (TSV), and thermal comfort (TC).

(a)



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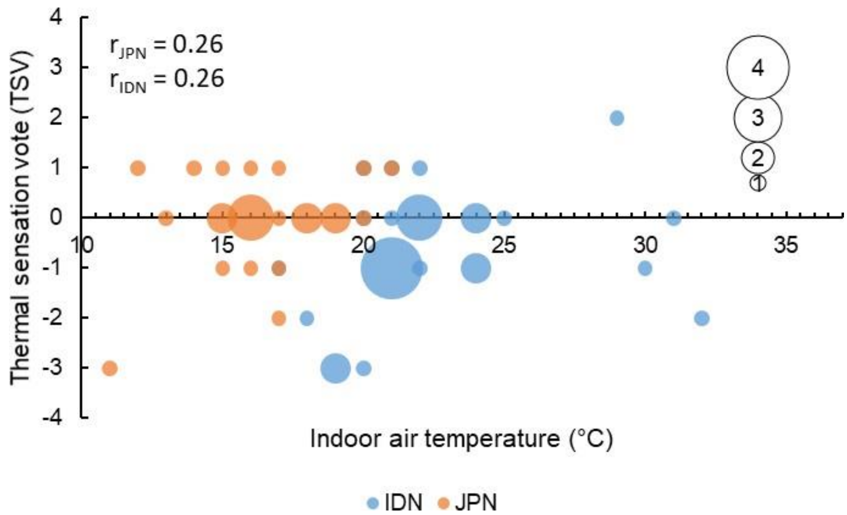
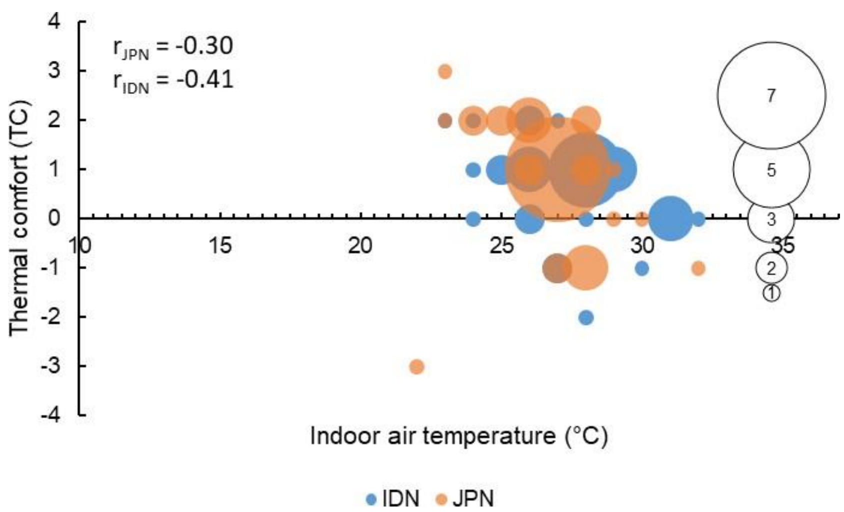


Figure 3. Frequency and correlation indoor air temperature and TSV during (a) Summer and (b) Winter; Abbreviation: IDN, Indonesian; JPN, Japanese

(a)



(b)

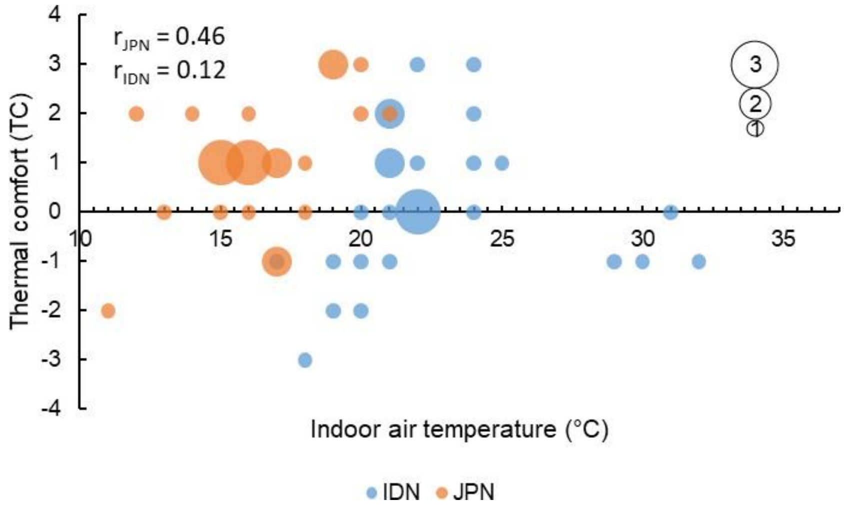


Figure 3. Frequency and correlation indoor air temperature and TC during (a) Summer and (b) Winter; Abbreviation: IDN, Indonesian; JPN, Japanese

Conclusion:

A thermal comfort survey and sleep quality of Indonesian and Japanese students of Toyohashi city (Chubu area of Japan) was conducted during summer and winter. The following results that we found in the current study that Indonesian students' duration on bed and sleep minutes were shorter than Indonesian students. Indonesian students woke up to follow the sunrise time. Although Indonesian students had shorter sleep minutes, the sleep rate was not different from Japanese students, and sleep sensation was better than Japanese students. The result showed that culture or religion has a significant contribution to encourage the sleep duration of Indonesian participants. The seasonal effect was found in the bedroom temperature and relative humidity. Indonesian students' average bedroom temperature was significantly higher in the winter than Japanese students' bedroom temperature. Moreover, indoor relative humidity of Indonesian students was significantly lower than Japanese students. Even though different, both of relative humidity in ASHRAE recommendation (30-60%). The significant difference in indoor air temperature and relative humidity between Indonesian and Japanese students caused by the difference of adaptation action during winter. Indonesian students set higher air temperature and wore clothing with lower clothing insulation than Japanese students. Each season's mean comfort temperature calculated using the Griffiths method was 28.1 °C for Indonesian and 26.1

°C for Japanese in summer. In the winter, the comfort temperature was 23.5 °C for Indonesian and 16.0 °C for Japanese. The comfort temperature of Indonesian students is surprisingly high.

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(Format Vancouver)

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Thermal response and sleep rate of Indonesian and Japanese students during summer and winter: a comparative research

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Statements: The authors confirm that the data supporting the findings of this study are available within the article. This research received no external funding. The authors declare no conflict of interest. Prior to conducting the research, the research ethics committee of Toyohashi University of Technology (TUT), Toyohashi, Japan issued approvals R1-11 and R2-09 / 2020.6.23. The research involved human participants, which was conducted according to the Helsinki Declaration's rules 1975 (2013). All participants of experiments have agreed to the experimental procedures and the publication of data. Permission to reproduce material from other sources was not applicable.

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Abstract

Providing comfort is complicated and it is the outcome of a flexible system including the occupant, the building, the indoor microclimate, and the outdoor climate. Thermal comfort is critical for occupant satisfaction and sleep quality. As foreigners, students from Indonesia need the effort to maintain comfort in sleeping in extreme weather such as winter. However, research discussing sleep comfort by foreigners still needs to be completed. To answer this challenge, the current research is focused to investigate the behaviour and subject preference for their indoor environment and sleep quality. Actigraphy was used to evaluate sleep activities. Prior to sleep, all participants completed a survey regarding thermal sensation, physical condition, and subjective sleep sensations. We noticed that Indonesian students had a considerably lower sleep rate than Japanese students. During the winter, Indonesian students' bedrooms were substantially warmer than those of Japanese students, according to the findings of this study. Using various heaters (air conditioners, electric heaters, and kerosene heaters), the majority of Indonesian students felt somewhat at ease and chose "warm" throughout the winter. The Griffiths approach revealed that the summer mean comfort temperatures for Indonesians and Japanese were 28,1 °C and 26,1 °C, respectively, while the winter mean comfort temperatures were 23,5 °C and 16,0 °C. In conclusion, the culture of Indonesian students improved their sleep performance. In addition, the disparities in adaptive response had an effect on the thermal environment of the bedroom.

Keywords: Thermal comfort, sleep quality, nationality differences, Indonesian, Japanese, seasons

1. Introduction

Our current world faces unparalleled global difficulties (environmental, geopolitical, societal, economic and technological). Globally excessive and irresponsible energy consumption is one of the primary causes of the complex environmental problems. Allowing building occupants to regulate and connect back to their immediate thermal environment, as well as to adapt to it, impacts the energy usage of the building itself. Also susceptible are long-term foreign residents during sleep, such as international students.

Numerous studies have documented seasonal variation in sleep and mood, in particular [1]. As we all know, sleep is essential for enhancing productivity and sustaining health at work and school. The human body is sensitive to atmospheric temperature during sleep [2]. Generally, uncomfortable temperature is connected with poor sleep quality and exhaustion [3]. Moreover, according to scientific research, there is a correlation between photoperiod and sleep length [4]. This difference in sleep duration between seasons may be due to ethnicity and culture [1], [5]. Nonetheless, research on the seasonal effect on sleep in individuals of different nationalities (as comparative research), particularly those who live in the same temperate zone, is scarce (e.g., Indonesia as foreigner) [5]–[7]. Numerous previous studies on indoor thermal environments, particularly the microenvironment (for example, the sleeping space or bedroom), have demonstrated that maintaining a comfortable temperature is critical for sleep quality [5], [8], [9].

Variation in indoor temperatures across seasons (e.g., summer and winter) may have a varying effect on sleep measures. The indoor and outdoor temperatures were highly correlated during the summer, while the opposite was confirmed during the winter [10]. Generally, thermal comfort is enhanced by following the guidelines of the applicable standard. However, thermal comfort standards (ASHRAE 55, ISO 7730) are universally applied to all individuals regardless of ethnic origin or nationality. In individuals from other countries, Havenith et al. (2020) have shown that incorporating an adaptive model with multiple standards for calculating thermal comfort in foreigners [11].

Therefore, we did a field assessment of thermal response of Indonesian and Japanese people. In addition, sleep quality was evaluated to identify the association between the actual bedroom's thermal environment and the participants' sleep quality. The primary first purpose is to identify what comfort means in terms of the temperature range for Indonesians, to examine the disparities, and to ascertain how tolerant the inhabitants are of their surroundings.

2. Methods

Summer 2019 and 2020, as well as winter 2020 and 2021, current research was conducted in Toyohashi city, Aichi prefecture, Japan (lat 34°46′9″ N, long 137°23′29.5″ E). Toyohashi is classified as having a Köppen-Geiger climate classification of Cfa: humid subtropical climate [12], [13]. Summers were hot and humid, while winters were relatively mild. The current investigation was done in a participant's house with a ventilation system of the same sort (natural). The current study did not specify the cooling and heating modes (NS).

The research ethics committee of Toyohashi University of Technology (TUT), Toyohashi, Japan, briefed and received written and approved consent from participants in this investigation. Participant responses to a subjective vote confirmed their physical and mental wellness. The participants were instructed to wear an actigraphy (Micro-mini, Ambulatory Monitoring, Inc., Ardsley, NY, USA) to measure the sleep quality parameters (duration on the bed, sleep duration, sleep rate, sleep efficiency, and sleep latency) and a thermal recorder (TR-74Ui, T&D Corp., Matsuyama, Japan) to measure the temperature and relative humidity of the bedroom environment during sleep. The following formulas were used to calculate the sleep rate and sleep efficiency. The following formulas were used to calculate the sleep rate and sleep efficiency.

$$sleep\ rate\ (\%) = \frac{sleep\ duration\ (minutes)}{duration\ on\ bed\ (minutes)} \times 100\% \qquad 1$$

$$Sleep\ efficiency\ (\%) = \frac{Sleep\ duration\ (minutes)}{sleep\ duration\ (minutes) + wake\ up\ duration\ (minutes)} \times 100\% \qquad 2$$

The bedroom's air temperature and relative humidity may be influenced by the type of home and the furniture. According to a previous study, proximity to heat or humidity sources (laundry, shower, kitchen) influences air temperature and humidity variation [14]. Moreover, the behaviour of respondents in the indoor thermal regulation might vary over the season [10], such as opening window [14], using fan/AC/heater [15], [16], and clothing and bedding [17], [18]. Thus, we instructed respondents to place the sensor and data logger closer and parallel to the head while sleeping. Accordingly, the participants completed a thermal comfort and physical condition survey before sleep and subjective sleep survey after wake-up. Researchers in this study did not control clothing, bedtime and wake-up time, and temperature.

Two sections questioner were applied in the current study. The first section contained demographic of participant questions (e.g., age and gender). In the second section, the questions were related to thermal sensation, thermal comfort sensation, thermal preference, and thermal satisfaction. The thermal sensation answer presented nine-point standards from the society of heating, air-conditioning, and sanitary engineers of Japan (SHASE) thermal sensation scale (4: very hot, 3: hot, 2: warm, 1: slightly warm, 0: neutral, -1: slightly cool, -2: cool, -3: cold, -4: very cold), seven-points of thermal comfort (3: very comfortable, 2: comfortable, 1: slightly comfortable, 0: neutral, -1: slightly uncomfortable, -2: uncomfortable, -3: very uncomfortable), three-points of thermal preference (1: prefer warmer, 0: prefer neutral, -1: prefer cooler), and five-points of thermal satisfaction (2: satisfied, 1: slightly satisfied, 0: neutral, -1: slightly unsatisfied, -2: unsatisfied).

Moreover, the physical condition survey was also completed before sleep. The physical condition survey was modified from previous study undertaken by Tsuzuki et al. (2011). The questionnaire consisted of 12 questions were written in English for Indonesian students and in Japanese for Japanese students. We used St. Mary's Hospital (SMH) as a subjective sleep survey. The SMH was adapted from previous studies undertaken by Shahid et al. (2012). In the SMH, the survey was completed after wake-up. The participants were asked to answer 14 questions about subjective sleep sensations.

The survey was designed as longitudinal (repeated measurements of same variables and a limited number of participants). The current study included participants of Indonesian students and Japanese students. This study was performed for three nights during summer and winter. The normality test was conducted by the Anderson-Darling test. If the normality hypothesis (*p* – value) under 0.05, a non-parametric test was used. Two sample t-test and analysis of variance

(ANOVA) were implemented in the current study. One-way ANOVA (nationality and season) for repeated measures was performed to analyse the indoor environment and sleep quality. All data were analysed using Minitab version 19 (Minitab, LLC, State College, PA, USA).

3. Results

In the current study, 68 healthy university students from 20 to 35 years of age participated in this study. The survey measured and obtained data for a total of 192 days. The 36 participants were Indonesian students (28.9 ± 3.9 years of age, 24.6 ± 4.0 kg/m^2 of body mass index), whereas 32 participants were Japanese students (22.9 ± 0.5 years of age, 20.7 ± 2.1 kg/m^2 of body mass index). This survey imposed no restrictions on the indoor environment, daytime activities, meals, clothing, or bathing time, and only required participants to sleep in their own bedrooms.

3.1 Indoor thermal conditions

In the winter, the average of indoor air temperature and relative humidity were significant different between Indonesian and Japanese students. The results of the investigation of the thermal environment in two seasons and two nationalities' bedrooms during sleep are summarized in Table 2. The total of sample point was 192. In the current study, sunrise was at 05:07 ± 19 min in summer and 06:27 ± 25 min in winter. Sunset was at 18:27 ± 28 min in summer and 17:25 ± 24 min in winter. The daylight hours were longer in summer (13 h 19 min ± 47 min) than in the winter (10 h 57 min ± 49 min).

Table 1 Average indoor thermal environment of participant's bedroom

	Summer		Winter	
	IDN	JPN	IDN	JPN
Bedroom Ta (°C)	26.5±2.2	26.1±2.0	22.2±3.7	15.9±2.4
Bedroom RH (%)	67±12	68±13	45±12	56±12
Bedroom AH (g/m3)	17.2±4.3	16.8±4.9	8.9±3.5	7.6±3.2
Clothing insulation	0.2±0.1	0.2±0.1	0.5±0.2	0.7±0.3
Bedding insulation	2.3±1.2	2.2±1.1	3.1±1.2	6.0±1.1

Abbreviations: AH, absolute humidity, IDN, Indonesian, JPN, Japanese, N, number of measurements

In addition, the temperature and relative humidity of the indoor air were categorized into 1°C and 10% bins, respectively. Figure 1 depicts the frequency distribution of indoor air temperature inside each bin. During the summer, the indoor air temperature that occurred most frequently was between 26 and 28 degrees Celsius for Indonesian and Japanese students. During the winter, the indoor air temperature was 20 °C for Indonesian and Japanese students and 21 °C for Indonesian students. Figure 2 depicts the frequency distribution of indoor relative humidity. The minimum indoor relative humidity was same for Indonesian and Japanese students during summer (35% of RH) and during winter (25% of RH).

The average indoor air temperature and relative humidity of Indonesian and Japanese students during the summer were comparable. However, the average indoor air temperature of Indonesian students during the winter was significantly higher than that of Japanese students ($p < 0.01$), while the average indoor relative humidity of Indonesian students during the winter was significantly lower ($p < 0.01$).

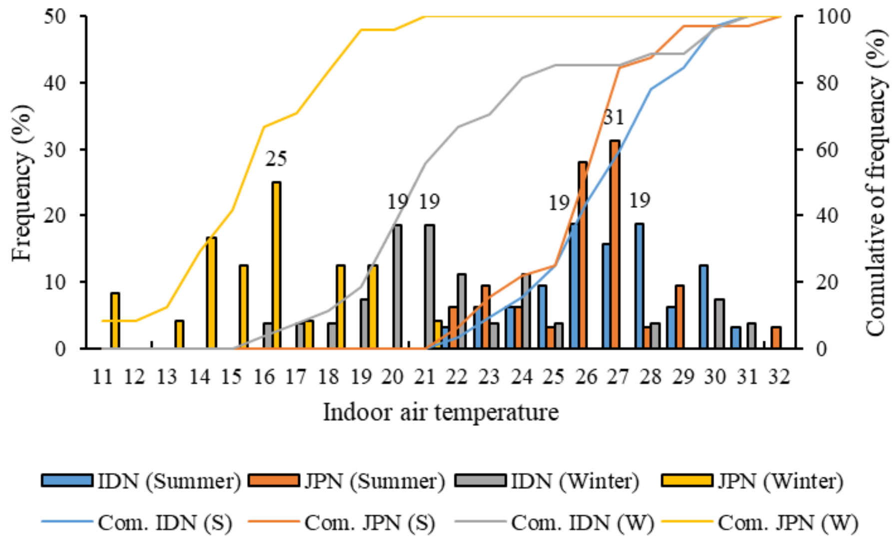

Figure 1 Frequency distribution of indoor air temperature; Abbreviation: IDN, Indonesian; JPN, Japanese; Com., cumulative; S, summer; W, winter.

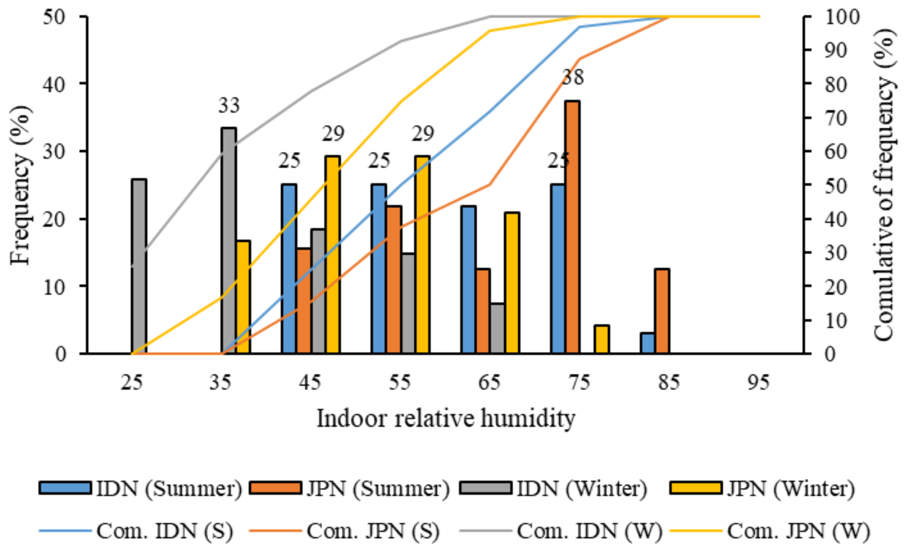

Figure 2 Frequency distribution of indoor relative humidity; Abbreviation: IDN, Indonesian; JPN, Japanese; Com., cumulative; S, summer; W, winter.

In the summer, 96.9 % and 84.4 % of Indonesian students, respectively, and 100 % and 78.1 % of Japanese students, respectively, slept in short sleeves and short pants. During the winter, 44.4 % and 33.3 % of Indonesian students, respectively, continued to wear short sleeves and short pants. By contrast, 95.8 % and 100 % of Japanese students, respectively, wore long sleeves and long sweatpants. In order to improve their sleeping comfort, Indonesian students protect their bodies with thick blankets on average during the summer and winter. However, Japanese students protected their bodies on average with a thin blanket and a very thick blanket during the summer and winter.

3.3 Sleep quality

In the summer, Indonesian students awoke at an average time of 5:49 a.m., while Japanese students awoke at an average time of 8:59 a.m. In the winter, on average, Indonesian students awoke at 5:53 a.m., while Japanese students awoke at 8:41 a.m. In the summer, 21.9 % of Indonesian students and 34.4 % of Japanese students napped during the day. In the winter, 16.7 % of Indonesian students and 12.5 % of Japanese students napped.

Table 2 Physical condition before sleep

	Summer			Winter		
Parameters	IDN	JPN	Sig.	IDN	JPN	Sig.
Physical condition (1 to 5)	3.0 ± 0.4	3.1 ± 0.5	$p = 0.62$	3.5 ± 0.7	2.9 ± 0.5	$p < 0.01$
Sleepiness (1 to 5)	3.2 ± 0.5	2.8 ± 1.0	$p < 0.05$	3.3 ± 0.6	2.8 ± 0.9	$p < 0.05$
Mental feeling (1 to 5)	3.0 ± 0.6	3.0 ± 0.6	$p = 0.84$	3.4 ± 0.8	3.0 ± 0.7	$p < 0.10$

Abbreviation: IDN, Indonesian; *JPN, Japanese*; Sig., significancy

Before sleeping in two distinct seasons, we attempted to examine the physical and mental states of the students. Table 2 summarizes the average subjective assessment of physical conditions. There were significant differences in sleepiness between Indonesian and Japanese students during the summer ($p < 0.05$). Students from Indonesia reported feeling drowsier than students from Japan. Between Indonesian and Japanese students in the winter, there were significant differences in all physical condition parameters (physical condition, sleepiness, and mental feeling) ($p < 0.01$, $p < 0.05$, and $p < 0.1$, respectively). Japanese students reported being in better physical condition during the winter than students from Indonesia.

Indonesian students went to bed at 23:49 (95 min) and woke up at 05:50 (108 min) and Japanese students went to bed at 01:20 (74 min) and woke up at 08:42 (39 min) during summer. In winter, Indonesian students went to bed at 23:30 (111 min) and woke up at 06:15 (76 min), and Japanese students went to bed at 01:19 (73 min) and woke up at 08:28 (73 min). There was significant different between wake-up time of Japanese student and sunrise time in summer ($p < 0.01$) and winter ($p < 0.01$). On average for all students, the sleep duration was 342 min (84 min) in summer and 358 min (97 min) in winter.

Based on actigraphy data, Table 3 presents the average of sleep quality metrics (duration on bed, sleep length, sleep rate, sleep efficiency, and sleep latency). The significant differences in sleep quality measures were detected between nationality and season. We performed an ANOVA on the sleep quality measures (duration on bed, sleep length, sleep rate, sleep efficiency, and sleep latency) with nationality (Indonesian, Japanese) and season (summer, winter) as the independent factors.

Table 3 Sleep quality parameters of Indonesian and Japanese students

	Summer			Winter		
Parameters	IDN	JPN	Sig.	IDN	JPN	Sig.
Duration on bed (min)	361.9 ± 62.1	442.2 ± 60.5	$p < 0.01$	406.1 ± 89.7	429.8 ± 102.3	$p = 0.69$
Sleep duration (min)	311.5 ± 72.9	370.9 ± 62.7	$p < 0.01$	338.3 ± 93.8	380.3 ± 99.4	$p = 0.24$
Sleep rate (%)	85.6 ± 10.3	84.6 ± 13.3	$p = 0.75$	82.7 ± 11.7	88.4 ± 8.2	$p < 0.05$
Sleep efficiency (%)	92.4 ± 8.5	91.1 ± 11.6	$p = 0.61$	88.5 ± 9.1	94.5 ± 5.9	$p < 0.01$
Sleep latency (min)	25.4 ± 24.7	28.8 ± 26.4	$p = 0.61$	24.7 ± 31.4	9.3 ± 15.0	$p < 0.05$

Abbreviation: IDN, Indonesian; JPN, Japanese; Sig., significancy

In the summer, the duration on bed and sleep duration were significantly different between Indonesian and Japanese students ($p = 0.00$, $p = 0.00$, respectively). Moreover, in the winter, we found the significant different of sleep rate ($p = 0.04$), sleep efficiency ($p = 0.00$), and sleep latency ($p = 0.03$).

We also analyzed sleep sensation (sleep depth, wellness, and clear-headed in the morning) using the St. Mary's Hospital (SMH) questionnaire and measured bedroom temperature 15 minutes after waking up. In the summer, there was a significant difference between Indonesian and Japanese in all parameters (sleep depth, wellness, and clear-headed in the morning) (*$p < 0.05$, $p < 0.01$*, and *$p < 0.01$*, respectively). Indonesian students felt better sleep experience than Japanese students during summer. In the winter, there were a significant different in wellness and clear-headed in the morning between Indonesian and Japanese (*$p < 0.1$, $p < 0.01$*, respectively). Although sleep duration of Japanese students was longer than Indonesian students, Indonesian students felt better in wellness and clear-headed in the morning than Japanese students.

Table 4. Sleep sensation of Indonesian and Japanese students

	Summer			Winter		
Parameters	IDN	JPN	Sig.	IDN	JPN	Sig.
Sleep-depth (1 to 8)	5.3 ± 1.2	4.5 ± 1.6	$p < 0.05$	5.0 ± 1.2	4.9 ± 1.5	$p = 0.69$
Wellness (1 to 6)	4.2 ± 0.7	3.6 ± 1.1	$p < 0.01$	4.5 ± 0.6	4.1 ± 0.9	$p < 0.10$
Clear-headedness (1 to 6)	3.9 ± 0.5	2.0 ± 0.6	$p < 0.01$	3.5 ± 0.8	2.3 ± 0.9	$p < 0.01$

3.4 Comfort temperature

Before going to sleep, participants completed questionnaires (thermal sensation and physical condition). The thermal sensation and thermal comfort percentages for each nationality in summer and winter prior to sleep are summarized in Table 5. In the summer, 41% of Indonesian students reported feeling slightly cool, compared to 41% of Japanese students. In winter, 33% of Indonesian students reported feeling neutral and slightly cool, compared to 50% of Japanese students. The highest percentage of Japanese students was feeling neutral during summer and winter, whereas the indoor air temperature was lower. Furthermore, in the thermal comfort sensation, 47% of Indonesian and 38% of Japanese students were feeling slightly comfortable during summer. In the winter, 26% of Indonesian students were feeling neutral and slightly uncomfortable, while 38% of Japanese students were feeling slightly comfortable.

Table 5 Percentage of each nationality's thermal sensation and comfort during summer and winter

Scale	Thermal sensation					Thermal comfort				
	Scale word	Summer**		Winter**		Scale word	Summer		Winter**	
		IDN	JPN	IDN	JPN		IDN	JPN	IDN	JPN
3	Hot	0%	0%	0%	0%	Very comfortable	0%	3%	7%	13%
2	Warm	0%	9%	4%	0%	Comfortable	16%	31%	11%	21%
1	Slightly warm	13%	16%	11%	29%	Slightly comfortable	47%	38%	19%	38%
0	Neutral	31%	41%	33%	50%	Neutral	25%	6%	26%	17%
-1	Slightly cool	41%	34%	33%	13%	Slightly uncomfortable	9%	19%	26%	8%
-2	Cool	16%	0%	7%	4%	Uncomfortable	3%	0%	7%	4%
-3	Cold	0%	0%	11%	4%	Very uncomfortable	0%	3%	4%	0%

Additionally, we examined the relationship between the two subjective sensations mentioned previously and the indoor air temperature. To calculate the frequency of correlation between physical and subjective measurements, the indoor air temperature was rounded to one degree Celsius. Figure 10 illustrates the frequency and correlation between indoor air temperature, thermal sensation vote (TSV), and thermal comfort (TC).

Additionally, we attempted to analyze the indoor environment's highest thermal preference prior to sleep. 41% of Indonesian and 59% of Japanese students were feeling neutral during summer. In winter, 63% of Indonesian students were feeling "prefer warm" and 67% of Japanese students were feeling "prefer neutral". During the summer, the mean temperature for students with a thermal preference (TP) of "0: neutral" was 26.3 °C for Indonesian students and 26.1 °C for Japanese students. In the winter, the temperature was 23.1 °C and 17.1 °C for Indonesian and Japanese students, respectively. The percentages of thermal preference are summarized in Table 6.

Table 6 Percentage of thermal preference each nationality in summer and winter

Scale	Thermal preference				
	Scale word	Summer		Winter**	
		IDN	JPN	IDN	JPN
1	Prefer warm	25%	0%	63%	33%
0	Neutral	41%	59%	37%	67%
-1	Prefer cool	34%	41%	0%	0%

Abbreviation: IDN, Indonesian, JPN, Japanese

Furthermore, we analysed correlation between thermal sensation, thermal comfort, and thermal preference (see Figure 6). During summer, the thermal sensation had a weak correlation with thermal comfort ($r = -0.32, p < 0.1$) and no correlation with thermal preference ($r = -0.16, p = 0.36$) for Indonesian students. For Japanese students during summer, the thermal sensation had a moderate correlation with thermal comfort ($r = -0.44, p < 0.05$) and a moderate correlation with thermal preference ($r = -0.48, p < 0.01$). During winter, the thermal sensation had a strong correlation with thermal comfort ($r = 0.58, p < 0.01$) and a strong correlation with thermal preference ($r = -0.59, p < 0.01$) for Indonesian students. For Japanese students during winter, the thermal sensation had a strong correlation with thermal comfort ($r = 0.58, p < 0.01$) and a strong correlation with thermal preference ($r = -0.59, p < 0.01$).

The mean of indoor air temperature for the thermal sensation vote (TSV) equalled to "-1, 0, +1 (extended neutral)" was 28.1 °C for Indonesian students and 26.2 °C for Japanese students during summer. Meanwhile, in winter, the mean of indoor air temperature for TSV was 22.1 °C and 17.0 °C for Indonesian and Japanese students, respectively. Rijal (2014) mentioned that linier regression model was not appropriate to predict the comfort temperature. Thus, we used Griffiths' method to predict each participant's thermal comfort temperature based on their TSV votes [22].

$$TC_g = T_a + \frac{(0 - TSV)}{\alpha} \quad (3)$$

where, TC_g is Griffiths comfort temperature, T_a is indoor air temperature (°C), and α is regression coefficient. Griffiths method was calculated using the following seven-point thermal sensation coefficients: 0.25, 0.33, 0.50 [23], [24]. The three regression coefficients for the nine-point thermal sensation in the current study were calculated using the Honjo et al conversion: 0.33, 0.44, 0.67 [25]. We observed TP using the same method. The following table summarizes the Griffiths method's calculation of the comfort air temperature.

Table 7 Average for comfort air temperature calculated by Griffiths method

		Summer			Winter		
	α	IDN	JPN	Sig.	IDN	JPN	Sig.
TC_g (°C)	0.33	28.6(2.2)	26.1(2.9)	$p < 0.01$	24.0(4.5)	16.0(3.4)	$p < 0.01$
	0.44	28.1(1.9)	26.1(2.5)	$p < 0.01$	23.5(3.9)	16.0(2.9)	$p < 0.01$

	0.67	27.7(1.7)	26.1(2.1)	*p < 0.01*	23.0(3.6)	15.9(2.6)	*p < 0.01*
	Avg	28.1(1.9)	26.1(2.5)	*p < 0.01*	23.5(4.0)	16.0(2.9)	*p < 0.01*
TP_g (°C)	0.33	27.1(2.8)	27.4(3.1)	*p = 0.68*	20.2(4.3)	14.8(3.4)	*p < 0.01*
	0.44	27.0(2.4)	27.1(2.8)	*p = 0.91*	20.7(4.1)	15.1(3.1)	*p < 0.01*
	0.67	26.9(2.3)	26.7(2.5)	*p = 0.78*	21.2(4.0)	15.4(2.9)	*p < 0.01*
	Avg	27.0(2.5)	27.1(2.8)	*p = 0.91*	20.7(4.1)	15.1(3.1)	*p < 0.01*

Abbreviation: IDN, Indonesian, JPN, Japanese, α, regression coefficient; N, number of measurements; TCg, comfort air temperature by Griffiths; TPg, preference air temperature by Griffiths

4. Discussion

The purpose of this study was to compare the thermal environment created by occupants for sleeping in the summer and winter seasons between Indonesian and Japanese students in Japan. Additionally, sleep quality was compared for Indonesian and Japanese students using quantitative and qualitative measurements.

As a result of Indonesia's location on the equator, the length of the day and the temperature of the air remain practically constant throughout the year. We had concerns about the Indonesian students' ability to control their bedroom's ambient thermal environment and maintain a healthy sleep environment during the Japanese winter season. Because the Indonesian students had never encountered a cold climate prior to their arrival in Japan. This contrasts with the residents of Japan who are forced to endure longer daytime hours during the hot summer and shorter daytime hours during the cold winter. Thus, this is the first study to compare the thermal environment and sleep parameters of foreign students from a different climate zone to those of local students.

The average bedroom temperature and relative humidity of Indonesian and Japanese students were comparable during the summer and different during the winter. The average bedroom temperature of Indonesian students was significantly higher than that of Japanese students during the winter. The reason for the Indonesian students' bedroom temperature being higher is due to their use of an air conditioner or heater during the night-time sleeping period. It differs from Japan's ministry of energy, trade, and industry recommendation, which recommends maintaining an indoor temperature at 20°C for maximum during the winter [26]. However, the Japanese students used the air conditioner only briefly before and after sleeping and did not leave it on during the sleeping period. Additionally, during the winter season, Japanese students slept on thick feather bedding and long-sleeved pajama with a long undershirt and long pants. This Japanese habit was discovered in current study and previous studies of Japanese children and adults. A study conducted on Japanese young people in Tsukuba, Japan for six months in a year (2-month intervals: February, April, June, August, October, and December) found that the ambient temperature before sleeping in December (winter) was 14.5 °C [27] and the average bedroom temperature was 10°C for elderly people in winter [28].

Indonesians' preference for high room temperatures in the winter may result in increased energy consumption. Previous research indicated that residents of developing countries consumed more energy than residents of developed countries [29]. According to Karyono (2000), air conditioning consumes twelve times as much energy as natural ventilation in Indonesia [30]. In addition, living as a foreigner necessitates time spent adapting to the various seasons, such as selecting seasonal clothing and bedding.

To get the comfort temperature value for each participant group, we evaluated the seasonal comfort temperatures of the participants. In the summer, the average comfort temperature for Japanese students was similar to that found in previous studies in Fukuoka (26.1 °C for males, 26.8 °C for females) [31], Tokyo (26.1 °C) [32], Osaka (27.6 °C) [33], and Kanto (27.1 °C) [34]. The current study found that Indonesians had a higher comfort temperature than Japanese students and previous studies conducted in Japan. However, a previous study determined that a thermal environment of less than 28.4 °C was acceptable [33]. While the Indonesians' comfort temperature was similar to that of previous studies (24-29 °C) conducted in Jakarta [30], [35]–[37], Bandung [37], Medan, Surabaya, and Makassar [35], and Jogja [35], [38]. According to the current study's findings, Indonesian students may accept the Japanese summer.

In the winter, Indonesian students preferred a warm environment, while Japanese students preferred a neutral environment. The average comfort temperature was also found to be different between Indonesian and Japanese students. The comfort temperature of Indonesian students was higher than that of Japanese students. As international students, Indonesian students' comfort temperature was higher than in a previous study conducted in the same city using a non-specific mode (22°C) [39]. This could be due to the fact that individuals of various nationalities are involved. The current study found that Japanese students' comfort temperature was lower than in previous studies using heating mode in Kanto (16.5 °C) [40] and Chubu (18.9°C) [32].

The current findings are the result of Indonesia's climate being predominantly classified as Af: tropical rainforest, Am: tropical monsoon, and Aw: tropical savanna with dry winter characteristics. It is generally warm (in 2020, the average air temperature was 27.3°C). According to this condition, Indonesian students were accustomed to warm temperatures but were unfamiliar with Toyohashi's winter conditions (mild). As a result, Indonesian students continued to use their bedroom heater or air conditioner during the night sleeping period. However, Japanese students used the heater or air conditioner in the bedroom only briefly before sleeping and turned it off when they went to sleep. Due to their previous residence in a tropical country, Indonesian students may have developed a long-term tolerance for heat (more than 20 years), which is similar to the case with Japanese Brazilians [41]. However, once established in a temperate zone (34°46'9" N Toyohashi, Japan), they will almost certainly require additional effort to adapt to their new environment. Not only is there a temperature difference, but also the time between sunset and sunrise varies by a maximum of 41 minutes [13]. This seasonal variability may have an effect on sleep quality and performance during the day.

Additionally, two nationalities demonstrated distinct thermal adaptive responses in summer and winter. In the summer, the two nationalities adopted nearly identical clothing choices: short sleeves and shorts. However, when it came to choosing a blanket, the average Indonesian student chose a thick one, while the average Japanese student chose a thin one. Some Indonesian students wore short sleeves and shorts during the winter. Because there was almost certainly a reaction to using an air conditioner with heating mode and electrical heaters while sleeping. Meanwhile, the majority of Japanese students wore long sleeved shirts, long sweatpants, and extremely thick bed sheets: mattrass, warmer mattrass cover, winter blanket, and winter blanket. Because Japanese students used an air conditioner with heating mode or an electric heater for a brief period prior to sleeping. They switched off the air conditioning or electric heater before going to bed. Tsuzuki et al. (2010) reported that Japanese adolescents wore clothing with a 1 clothing insulation index for 16.2 °C prior to going to sleep, and that this number will be higher at lower ambient temperatures [19]. Although the study's sample size was small, the Japanese students slept in high-quality bedding insulation. These habits regarding clothing selection and air conditioning use may have an effect on the indoor temperature, thermal sensation, and sleep quality of Japanese and Indonesian students. However, sleep quality was nearly identical between Indonesian and Japanese students during the summer, while sleep efficiency was lower for Indonesian students than for Japanese students during the winter, despite the fact that Indonesian students chose a warmer bedroom temperature than Japanese students.

In the sleep survey, there was a significant difference in the wake-up time of Japanese students in the sleep quality study. The average duration of sleep for all students was 342 minutes (84 minutes) in the summer and 358 minutes (97 minutes) in the winter. This finding corroborated a previous study that winter sleep duration was greater than summer sleep duration [1], [42]–[44]. The current study's average difference (16 minutes) was comparable to Suzuki et al (2019): 11.4 minutes [1]. Additionally, Suzuki et al. (2019) explained that this difference is due to a variety of factors, including the sampling process, climate, ethnicity or race, and culture or behavior [1]. Seasonal differences in day length between winter and summer may be a significant factor in seasonal sleep duration.

We found that duration on bed, sleep duration and sleep efficiency were significantly different between Indonesian and Japanese. There was no significant difference in sleep rates between Indonesian and Japanese in the two seasons. The duration on bed and sleep duration of Japanese students were longer than Indonesian students in summer and sleep efficiency of Japanese students was higher than Indonesian students in winter. 34 of the 36 Indonesian participants were Muslims who worshiped in the morning before sunrise. We discovered that there was no difference in the times of waking up and sunrise. Actigraphy measurements indicated that the Indonesian participants' waking time coincided with sunrise. Japanese participants, on the other hand, awoke later than Indonesian students. In sleep subjective sensation, all parameters (sleep depth, wellness, clear-headed in the morning) of Indonesian students showed better than Japanese students during summer. In the winter, although sleep duration of Japanese students was longer than Indonesian students, Indonesian students felt better in wellness and clear-headed in the morning than Japanese students.

5. Conclusion

A thermal comfort survey and sleep quality of Indonesian and Japanese students of Toyohashi city (Chubu area of Japan) was conducted during summer and winter. The following results that we found in the current study that Indonesian students' duration on bed and sleep minutes were shorter than Indonesian students. Indonesian students woke up to follow the sunrise time. Although Indonesian students had shorter sleep minutes, the sleep rate was not different from Japanese students, and sleep sensation was better than Japanese students. The result showed that culture or religion has a significant contribution to encourage the sleep duration of Indonesian participants. The seasonal effect was found in the bedroom temperature and relative humidity. Indonesian students' average bedroom temperature was significantly higher in the winter than Japanese students' bedroom temperature. Moreover, indoor relative humidity of Indonesian students was significantly lower than Japanese students. Even though different, both of relative humidity in ASHRAE recommendation (30-60%). The significant difference in indoor air temperature and relative humidity between Indonesian and Japanese students caused by the difference of adaptation action during winter. Indonesian students set higher air temperature and wore clothing with lower clothing insulation than Japanese students. Each season's mean comfort temperature calculated using the Griffiths method was 28.1 °C for Indonesian and 26.1 °C for Japanese in summer. In the winter, the comfort temperature was 23.5 °C for Indonesian and 16.0 °C for Japanese. The comfort temperature of Indonesian students is surprisingly high.

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