OUTDOOR THERMAL COMFORT (OTC) IN HUMAN INTERACTION-BASED STUDIES: AN OVERVIEW OF REVIEWS

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ABSTRACT

The past two decades have shown substantial growth in Outdoor Thermal Comfort (OTC) studies. This work presents an overview of twelve review articles on OTC studies, five general categories of investigation to date are identified: objective parameter-based models; subjective parameter-based models; design strategies; computational algorithm-based models; and human interactions. A key finding of this overview is the upcoming new school of thought involving comprehensive frameworks for OTC assessments. Due to the increased popularity towards this approach, the authors suggest the development of a standardized model based on this framework. Additionally, this paper presents a detailed review of recent studies on OTC and human interactions based on three topics: OTC assessments; typologies of outdoor public spaces; and human behavior. The findings of this analysis provide insights into the state of art of human activity-based OTC research.

INTRODUCTION

Outdoor public spaces play a key role in cities contributing to healthy sustainable communities (US Department of Agriculture, 2018). Human behavioral studies in the climatic context of outdoor spaces have shown direct impact on social and economic phenomena in the built environment (Nikolopoulou and Lykoudis, 2007). The success of public spaces is determined in part through human attendance rates, which show direct relationships to outdoor thermal comfort and microclimatic conditions (Carmona et al., 2012).

Outdoor Thermal Comfort (OTC) is a complex topic widely studied from conceptual development to its application in building science, urban design, and social science and that affects global issues related to climate change, public health, economic upliftment, urbanization and many more. This paper presents a review of the current state of the art for OTC studies, especially focused on those involving human interactions within the built environment. The findings from the first section of the OTC reviews form a premise for a detailed analysis in the second section aiming towards: (1) identifying research gaps and (2) analyzing the popular methods of OTC assessments.

OUTDOOR THERMAL COMFORT REVIEWS, 2000-2018

This section presents an overview of twelve OTC review articles published since 2000. The selection of the literature is based on a literature search for keywords ‘outdoor thermal comfort’ and ‘outdoor human comfort’ in ScienceDirect, Google Scholar, and Springer Link databases. This review identifies five overarching categories of investigation: (1) OTC models with objective parameters; (2) OTC models with subjective parameters; (3) OTC and design strategies; (4) OTC models using computational algorithms; and (5) OTC and human interactions. The first two topics on OTC models have been discussed in eleven of the twelve review articles (Figure 1), while OTC and design strategies are found in three review articles. The other two topics have been observed in only one review article to date. Additionally, the last literature review for category 5 (OTC and human interactions) dates back to 2012, creating a research gap for studies in this category.

Overview of review in OTC assessment

OTC is a complex phenomenon initially considered to be a function of primarily climatic parameters (Zacharias, 2001). Pioneering studies demonstrated strong interrelationships between microclimate and human interaction (Nikolopoulou et al., 2001). Thermal perceptions (impacted by microclimatic variables) was shown to affect peoples’ behavior in the spaces (Lin, 2009). For instance, people preferred to be in sunny areas than shaded areas in winter, and vice versa in summer, showing the effect of sunlight and solar radiation on human activities (Chen et al., 2015; Lai et al., 2014; Lin et al., 2012). This direct adaptation is referred to ‘physical adaptation’ in many studies (Chen and Ng, 2012; Nikolopoulou and Steemers, 2003). Subsequently, physical adaptation was complimented with thermo-physiological factors. Thermal indices based on heat balance models were studied to explore the interrelationship between climatic parameters (air temperature, wind velocity, relative humidity and mean radiant temperature), clo-value and metabolic rate of human body (Coccolo et al., 2016). Human heat balance was quantified through factors including but not limited to heat budget, perspiration rate, skin and core body temperatures, multi-nodal heat transfer, and many more. Some of the popular indices used to date are Predicted Mean Vote/ Predicted Percentage of Dissatisfied (PMV/PPD) (Fanger, 1982), Physiological Equivalent Temperature (PET) (Höppe, 1999), Outdoor Standard Effective Temperature (OUT_SET*) (de Dear and J., 1999), and Universal Thermal Climate Index (UTCI) (Fiala et al., 2012).

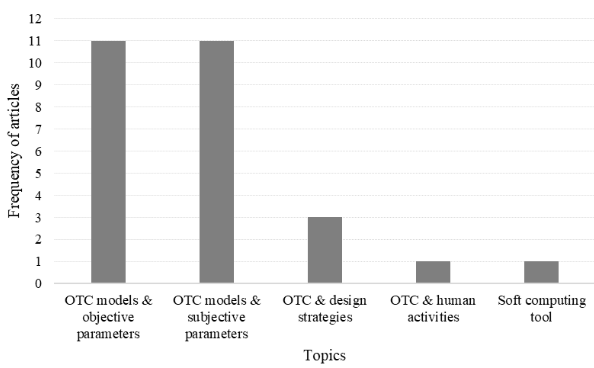

Figure 1 Frequency of categories of topics in OTC studies (Source: authors)

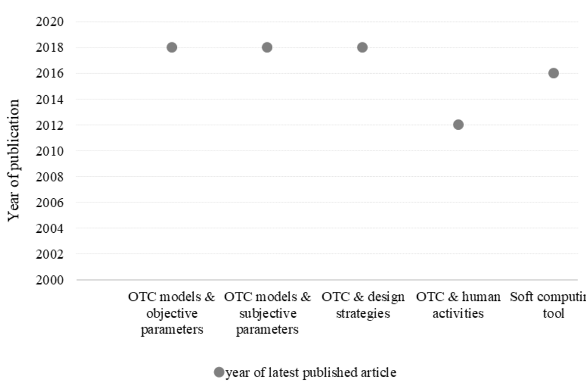

Figure 2 Frequency of topics in OTC studies and the year of last publication for each topic (Source: authors)

Psychological aspects were later added to OTC assessment methodologies through empirical indices such as Thermal Sensation Votes (TSV) and Actual Sensation Votes (ASV). Nikolopoulou and Steemers (2003) presented six parameters of psychological adaptation that affects the OTC assessment including naturalness, expectations, experience, time of exposure, perceived control, and environmental stimulation (Nikolopoulou and Steemers, 2003). They claimed that physical parameters account for 50% of OTC assessment while the rest relies on psychological adaptation. This research was a pioneering study that clearly demonstrated psychological parameters as a causal factor in OTC assessments.

The most recent additions to OTC assessments are behavioral aspects (Chen and Ng, 2012) and social/cultural (Chen et al., 2015). Chen and Ng (2012) outlined the OTC assessment framework as a combination of physical, physiological, psychological, and social/cultural aspects (Chen et al., 2015; Chen and Ng, 2012). Although social aspects (also referred as behavioral aspects) are identified as the fourth aspect, the study lacked an explicit in-depth elaboration of the concept. Nevertheless, this comprehensive framework seems to have been largely sorted into two main categories. The first category is 'objective,' based on physical (climatic) and physiological aspects of adaptation. The second category is 'subjective,' based on psychological and behavioral aspects of adaptation (Nikolopoulou et al., 1999). Objective assessment factors are also referred as 'thermal indices' (Coccolo et al., 2016), 'rational indices' (Li et al., 2016), or 'static' indices (Shooshtarian and Ridley, 2016). Subjective assessment factors are commonly referred to as 'empirical indices' or 'adaptive' indices (Shooshtarian and Ridley, 2016).

These two broad categories have generated two main schools of thought – namely objective and subjective – that have tried to prove their degree of relevance to OTC assessment. Additionally, recent research has led to the development of a third category that believes in a combination of the two ideologies, where both can complement each other instead of competing (Shooshtarian and Ridley, 2016). This group clearly captures the limitations of the other two groups. ASHRAE defines 'thermal comfort,' as "the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation." Objective models do not comply to this definition since it does not include the psychological aspects. Whereas subjective models are very region-specific limiting its applicability at a global level unlike the objective models. One of the interesting findings in recent studies with comprehensive OTC assessment approach is the correlation between the two models (Li et al., 2016; Chokhachian et al., 2018).

The next finding of this review is presented in terms of topical categorization in OTC models. This approach is different from the reviewed literature, where popular

OTC model(s) and their applications/ limitations remain their focus area (Chen and Ng, 2012; Honjo, 2009) except for the two studies which present a category based comprehensive list of all 165 thermal comfort indices. (de Freitas and Grigorieva, 2015).
The study analyzes five topics discussed below.

OTC models with objective parameters

This category of models evolved as a result of quantitative parameters discussed in the earlier section. They resulted from the physical (climatic) and physiological factors of OTC assessment framework. Coccolo et al. (2016) reviewed 23 indices, based on their popularity, and categorized them into thermal, empirical, and linear equation (Coccolo et al., 2016). Of these three, thermal and linear equation-based indices stem from objective parameters. Some thermal indices listed in this study are: COMFA model (1995), Universal Effective Temperature (ETU), Index of Thermal Stress (ITS), Man Environmental Heat Exchange Model (MENEX), Physiologically Equivalent Temperature (PET), Predicted Mean Vote (PMV), Perceived Temperature (PT), New Standard Effective Temperature (SET*), Outdoor Effective Temperature (OUT-SET*) and Universal Thermal Comfort Index (UTCI). Indices based on linear equations incorporate only three parameters of thermal environment in human comfort assessment (air temperature, wind speed and relative humidity). These are Apparent Temperature (AT), Discomfort Index (DI), Environmental Stress Index (ESI) and Physiological Strain Index (PSI), Effective Temperature (ET), Humidex (H), Heat Index (HI), Cooling Power Index (CPI), Relative Strain Index (RSI), Wet Bulb Globe Temperature Index (WBGT), Wind Chill Index (WCI).

OTC indices with subjective parameters

OTC indices with subjective parameters are mainly based on psychological aspects of human thermal perceptions. Coccolo etal. (2016) refers to this cluster as empirical indices (Coccolo et al., 2016). Empirical indices define "the human comfort for a specific climate and are expressed as models based on field studies (on onsite monitoring and surveys)" (Coccolo et al., 2016). These are Actual Sensation Vote (ASV), Thermal Sensation (TS) and Thermal Sensation Vote (TSV). Since the non-thermal factors are studied at individual level and in a particular climatic context, the results cannot be generalized in global context. Johansson et al (2014) and Potcher et al (2018) in their review papers discuss these factors in detail along with methods and instruments used to determine the OTC levels.

OTC models using computational algorithms

This category encompasses computational tools rather than usual statistical tools such as Extreme Learning Machine (ELM), Genetic Programing (GP), Artificial Neural Networks (ANN) to predict OTC assessments. It includes subjective and objective parameters to model OTC. Kariminia et al (2016) presents an analysis on three computational models for OTC studies (Kariminia et al., 2016).

OTC and design strategies

This section discusses various strategies to mitigate heat stress and improve thermal comfort levels in outdoor public spaces. A review by Taleghani (2018) explores passive methods to reduce urban heat island effect through vegetation and high albedo material (Taleghani, 2018). Similarly, Shooshtarian etal. (2018) presents a new clustering method called 'Adaptation to Outdoor Climate' (AOC) model, to classify various methods for heat mitigation (Shooshtarian et al., 2018). The clusters he identifies are (1) 'environmental & technological modifications' (2) 'behavioral adjustments' and (3) 'psychological adaptation'; where the first cluster is highly developed as against the other two. Finally, a review by Jamei et al (2016) focused on urban geometry and street level greening to summarize its effects on thermal comfort levels (Jamei et al., 2016).

OTC and human interactions

This category includes OTC studies that directly involve human interactions with built environment, commonly identified as 'human activities' or 'human behavior.' It focuses on the impacts of physical built form and its microclimates on human behavior. These studies have either explored different typologies of physical built forms in the same climatic context or the same typology of built form in different climatic contexts (Klemm et al., 2015; Lin et al., 2012; Shooshtarian and Ridley, 2016). The parameters of built form mainly deal with sky view factors, aspect ratio (height vs width), or the site orientation. They investigated space use patterns in sunny and shaded conditions of built forms (Lin et al., 2012). This study identified only one review article by Chen & Ng (2012) that assessed literature until 2010. Ample research in this category is available beyond this study and has not been reviewed to date. This paper attempts to fill this gap by building on the review by Chen & Ng (2012).

LITERATURE REVIEW ON OTC AND HUMAN INTERACTIONS:

The literature focusing on OTC and human interactions in outdoor public spaces consists of a total of twenty-three research articles, one review article, one dissertation, and one conference proceeding (see Table-1). The literature sources were selected using keywords such as ‘outdoor thermal comfort,’ ‘outdoor activities,’ and ‘outdoor thermal environment’ in ScienceDirect and Springer Link databases. Figure 3 depicts a recent increase in interest on this research topic. This paper presents a current discussion trend by drawing commonalities and differences in the reviewed literature.

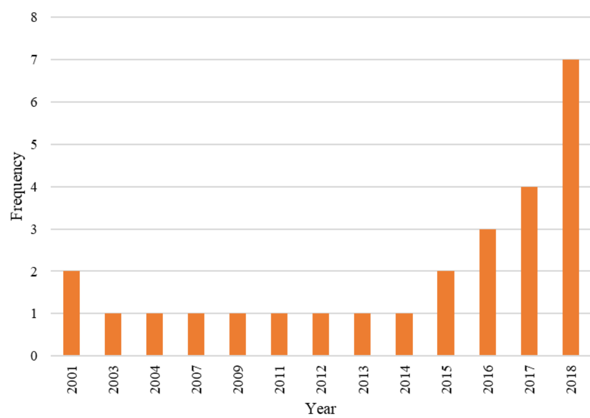

Figure 3 Trend in frequency of publications on OTC and human activities (Source: authors)

OTC is a function of environmental (climatic), behavioral (social), physiological, and psychological factors (Chen and Ng, 2012). Due to the limited scope of this paper, only the former two topics have been included in this study. Environmental factors are studied at climatic level use Koppen Climatic Classification (arid, cold, polar, temperate, and tropical). Additionally, typologies of outdoor public spaces creating unique microclimates have been studied, to understand the impact of climate on thermal perceptions of people in different location. Behavioral aspects include human activities which is a function of human interactions and space usage (Aggarwal and Ryoo, 2011).

The research seeks answers to the following questions within the premise of the literature:

- Which popular OTC assessments exist in human interaction-based research?
- How do thermal comfort levels change with locations based on climatic classification?
- How do different typologies of outdoor public spaces affect the OTC assessment?
- What human behavior is popular in outdoor public spaces in different climatic context?

Result 1: Popular methods of OTC assessments

There exist numerous thermal comfort indices (de Freitas and Grigorieva, 2015) but the analysis shows only few being frequently used in human interaction-based OTC studies. Figure 4 shows the percentage distribution of different indices used in OTC studies focused on human behavior. ASV, TS and TSV have appeared in fourteen studies (28%), followed by PET and Climatic variables such as Solar Radiation, Temperature (T), Wind Speed (Ws) and Relative Humidity (RH) which were found in eleven and ten studies, respectively. Although UTCI is very recently evolved, it holds around 14% of the total frequency weightage which shows its popularity in recent articles. Further analysis in this topic showed that more than 50% of the studies used a comprehensive OTC assessment framework instead of using either subjective or objective models only (Figure 5).

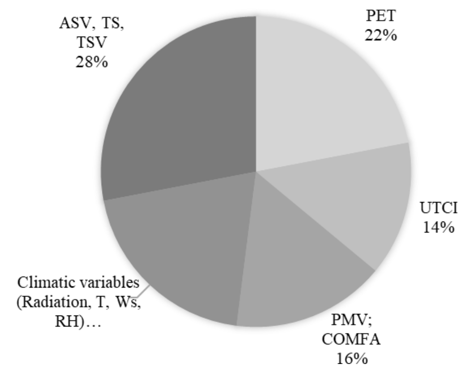

Figure 4 OTC indices researched in human interaction-based OTC Studies (Source: authors)

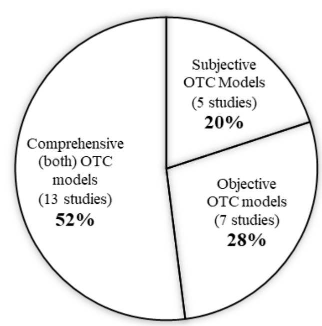

Figure 5 Frequency distribution of OTC indices researched in human interaction-based OTC Studies (Source: authors)

Result 2: Climatic classifications and OTC models

OTC levels are specific to location and climate, especially when it directly impacts the human behavior in the space. The study locations for the reviewed literature were mapped to see the research extent at a global level (Figure 6). Further, a comparative analysis (Figure 7) was conducted using the percentage distribution of OTC models in different regions to understand the popularity of methods in different cities.

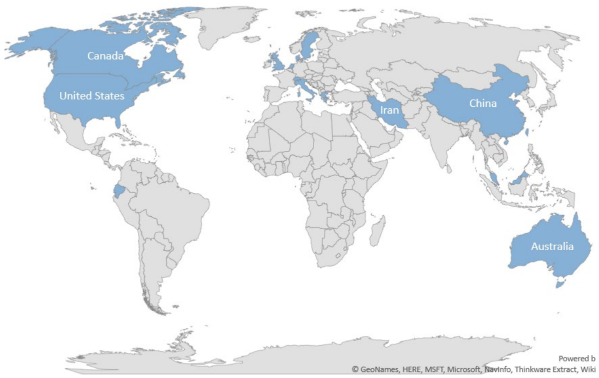

Figure 6 Locations of OTC studies based on human activities (source: authors)

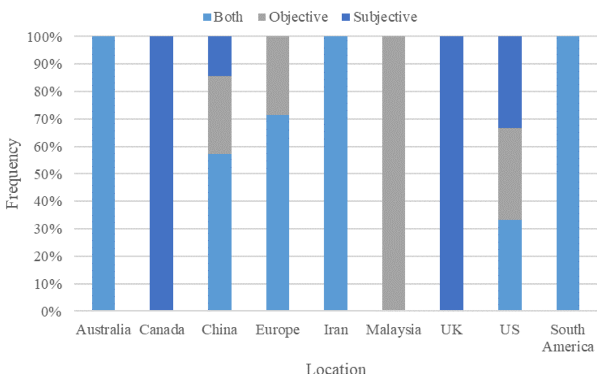

Figure 7 Frequency of OTC indices in different studied locations (Source: authors)

Further, to understand a broader climatic impact on OTC levels, Koppen climate classification is introduced, and the data is overlapped with study locations (Figure 8).

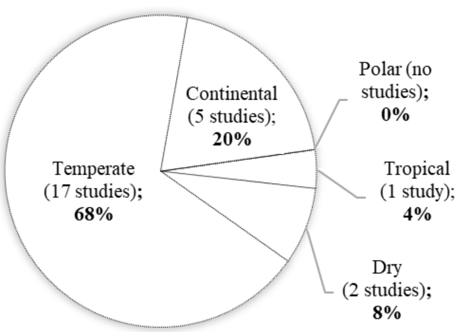

Figure 8 Frequency of OTC studies in Koppen climate classification (Source: authors)

Result 3: Typologies of public outdoor spaces

Outdoor public spaces are one of the key components of urban morphology. They foster public life and are designed in the form of plazas, parks, streets, playgrounds, shaded areas, etc. We have identified 5 types of outdoor spaces studied in this context demonstrating the popularity of urban physical forms. Figure 9 shows plazas as the most popular built form studied appearing in 14 researches (39%), followed by green spaces: Parks with 10 (28%) and street / canyon with 5 (14%) and the rest about 19%. The shaded area in these studies is either a shaded private street or semi-open space at ground level under a building.

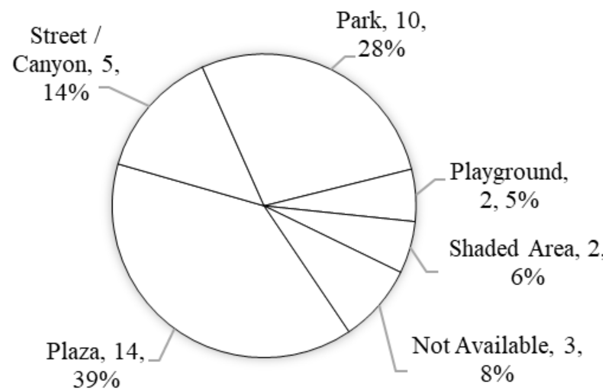

Figure 9 Percentage distribution of types of outdoor public spaces researched in human interaction-based OTC studies (Source: authors)

Result 4: Human behavior in OTC studies

Human behavior or human activity results from human interaction with its built environment. Although human interaction occurs at different level such as the physical urban form, the climate, the land-use or the programmatic distribution, the socio-cultural aspect and many more, this review focuses on understanding the inter-relationship between human behavior, outdoor public space typologies and OTC models.

Different activity types have been identified in the review of human interaction-based OTC studies. There can be various ways to categorize these activities. This study adopts the categories used by Huang et al. (Huang et al., 2016) where activities are divided into three groups based on the intensity level of Metabolic Equivalent (MET) ("WHO | Physical Inactivity," n.d.). These are light, moderate and intense activities. Chart on percentage distribution of researched human activities in OTC studies (Figure 10) show that 'light activity' has been researched the most with 44% as against 'intense activity' with only 20% of the total studies. Further, the Figure 11 show that walking, standing and sitting have been studied more often than others.

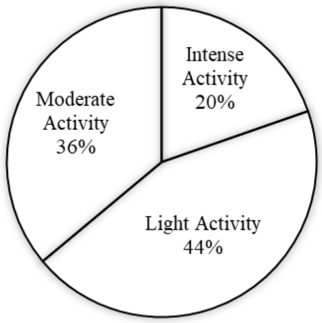

Figure 10 Percentage distribution of human behavior studies based on MET level classification of activities (Source: authors)

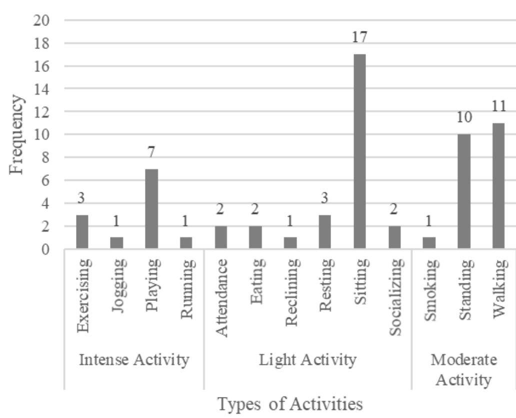

Figure 11 Frequency of activity types in human interaction-based OTC studies (Source: authors)

These activities were further studied in relation to the typologies of public open spaces (Figure 12), the Koppen climate classification (Figure 13), and the types of OTC models (Figure 14).

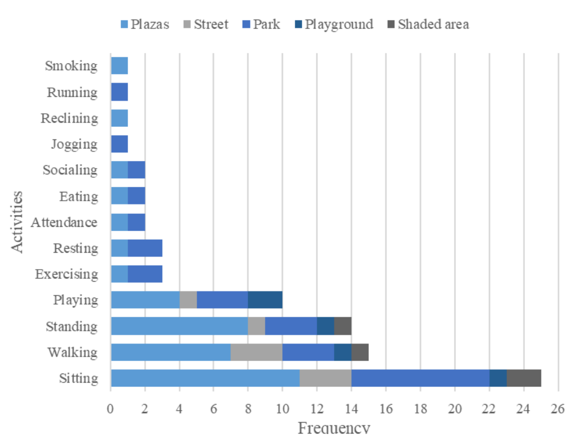

Figure 12 Comparison chart of different activities researched in five types of outdoor public spaces (Source: authors)

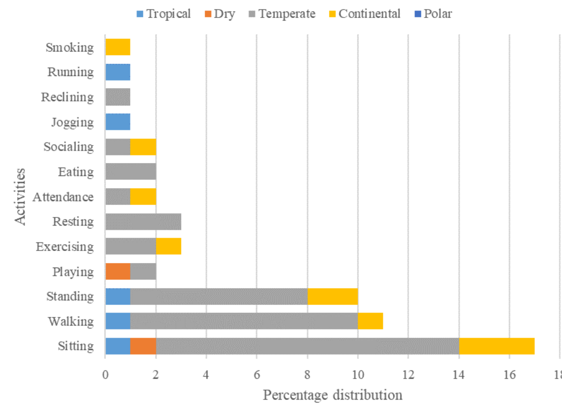

Figure 13 Comparison chart of different activities in Koppen climate classification (Source: authors)

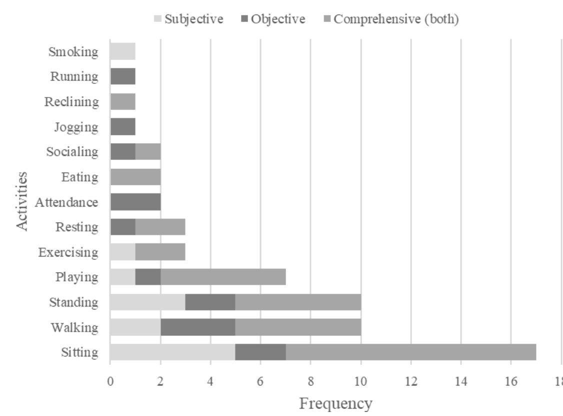

Figure 14 Comparison chart of different activities researched in OTC models (Source: authors)

Discussion

The findings of this systematic overview highlight the introspective relation between human activities, thermal indices and public space typology. One of the major findings feature the popular OTC model for human activity-based research. Although, Figure 4 demonstrates the popularity of subjective OTC indices namely ASV, TSV, and TSENS as against objective ones namely UTCI, PET, SET*, etc., it is interesting to see the increasing trend of a comprehensive OTC assessment framework using both subjective and objective indices, over the last few years (Figure 5). The framework encompasses physical, physiological, psychological and social/ behavioral aspects of thermal comfort sensation (Chen and Ng, 2012). It is recommended to devise a standardized model based on this framework that can be used globally. This would require a large body of interdisciplinary research worldwide especially in social / behavioral and psychological areas. Our findings provide insights into this by presenting the state of the art of human activity-based research.

As one of the inquiry tasks, this study reviewed the studied locations and climates in OTC research. It is found that developing nations have not been well studied as compared to the developed nations, thus creating great research opportunities in these places (Figure 6). Further, the comparative distribution of OTC models in different cities do not show the use of a comprehensive framework (Figure 7). Most of them have either used subjective models or objective parameter-based OTC models instead of both, except for US and China. It is recommended that researchers should include both of the model types to obtain a wholistic understanding of the topic. We also noted that regions with temperate climates are extensively studied (about 68%), followed by continental climates (about 20%), and very little work in dry-arid and tropical areas, and none for polar climate regions (Figure 8). We encourage research in these areas to ensure a wider spectrum of knowledge in climatic context. The findings from the reviewed literature (Table-1) show a strong relation between human behavior and contextual climatic influence. For instance, the studies in Europe, China, Malaysia and Iran represented temperate, subtropical, tropical, and mediterranean climates respectively. These studies show that human attendance increases in temperate climates as thermal indices increase in cold and hot seasons. Similarly, for subtropical climates (hot and humid) the increase in thermal indices resulted in higher human attendance for winter but lower for summer (Table-1). Results from these contextual differences can be standardized if more studies are available on human attendance in different climatic context as the psychological and social factor of OTC comprehensive model.

It is proposed that other human behaviors or activities should be considered along the similar lines. To support this, we extended our review to understand the state of the art in the type of human activities for OTC research (Figure 11-14). The results in Figure 13 show a comparison of different activities studied in the Koppen climate classification context. It is found that most of the activities were studied in temperate climates, followed by continental and very minimal in the other three. This suggests that there is a need to research different human activities in all of the climatic contexts except temperate climate regions, especially in tropical climates where outdoor activity is very prominent. A similar analysis comparing OTC models studied in different activities (Figure 14) showed that most of the activities have been studied in the comprehensive OTC assessment framework unlike in sole conditions of subjective or objective OTC models which are very few.

Along with the climatic region and human activities as the criteria of investigation, we also analyzed the typology of outdoor public spaces in OTC studies. The built forms containing the outdoor public spaces create microclimates that affects people's thermal perception (Sharmin et al., 2015). Out of the five typologies identified, our findings show that urban plazas and parks have been studied the most, followed by streets (Figure 9). One of the distinct attributes of urban plazas / parks and streets is the static and dynamic built form respectively which affects the activities of people inhabiting them. Our findings on the type of human activities and typologies of outdoor spaces show that most of the activities are studied in 'parks' and 'plazas' while 'streets', 'shaded areas' and 'playground' show 3-4 activity types only (Figure 12). People have more choice of activities in the former two typologies while the later three provide very limited and specific activities. However, this is not always true for 'streets' as it resembles rest areas depending upon its location. Hence, it is suggested that OTC studies for canyon/ streets as outdoor space typologies should be investigated further, especially in medieval cities of Asia and Europe, where it is more than a channel of walking people.

Another important result relates to the popular activities in OTC studies. We found that at a category level, light activity is studied more (about 44%) than moderate (about 36%) or intense activities (about 20%) as seen in Figure 10. Sitting, as a light activity is studied the most (in about seventeen studies) followed by standing (ten studies) and walking (eleven studies) as shown in Figure 11. One of the likely reasons for this is that sitting is a static activity whereas walking or playing are dynamic activities related to non-steady state of thermal comfort which are more difficult to assess (Chen and Ng, 2012; Höppe, 2002). Steady state models are easier to work with and have better accuracy than non-steady state. This finding highlights the need to study thermal comfort in transient state.

This literature review highlights different facets of comprehensive OTC assessment framework for human activity-based OTC research. Although exploring research methods in this topic area would be another study in itself, we would like to highlight some gaps in data collection found in this literature. Data in subjective parameter-based OTC models are based on regression analysis. The accuracy of their results depends on the sample population of the data (Lai et al., 2014). Most of the studies are based on smaller sample sizes instead of larger sample, resulting in lower statistical power or inflated effect size estimation which both affect the accurate interpretation of findings. Apart from the sample size, the time duration considered for the sample affects the accuracy of data sets. For instance, transverse studies tend to ignore the 'thermal history' (Reinhart et al., 2017) and precision in activity patterns, unlike longitudinal studies which are very rare due to the uncertainties associated with the time commitment and data accessibility. Hence, innovation in research methodologies for OTC studies should be a key area of investigation. Additionally, not all studies provide a wholistic picture of all activities taking place in a space. We suggest a standardized questionnaire format comprising a range of plausible activities for human activity-based OTC research. On the other hand, some studies using objective parameter-based OTC models have used some methods like video data, Wi-Fi scanners and mobile phone locations to mine data for human behavior (Reinhart et al., 2017; Santucci et al., 2018).

CONCLUSION

In this paper, studies on OTC and human activities are analyzed systematically beginning with an overview of OTC review articles that identifies a gap for literature review in human activity-based OTC studies. This study is a continuation of the review by Chen et al. (2012) and highlights the increase in human activity-based research. It identifies comprehensive OTC assessment framework as the most popular and effective model in this area of research. Additionally, the study investigates the latest trends and gaps in the literature through the lens of geographic location, climatic context, and human activities. It is suggested that addressing the findings of these investigation criteria, the comprehensive OTC assessment framework could be developed into a robust tool.

One limitation of this research includes its selection process of case studies, which was limited to three databases available to the authors. It is possible that the findings might vary if research in another database uncovers other review articles not included herein. Future research could be conducted to expand the knowledge along the same structure of the investigation.

Table 1 Findings from the reviewed literature on OTC studies and human interaction (Source: author)

STUDIES	FINDINGS
(Nikolopoulou et al., 2001)	Thermal neutrality for OTC varies from 7.5°C in winter to 27°C in summer
(Zacharias et al., 2001)	People's presence shows strong relations to temperature & solar radiations
(Nikolopoulou and Steemers, 2003)	Proposed six psychological factors in OTC assessment, found through physical adaptation
(Thorsson et al., 2004)	People prefer higher mean radiant temperature and adapt through clothing; posture & position
(Nikolopoulou and Lykoudis, 2007)	People's presence is affected by diurnal & seasonal climatic variations, and temperature, wind & solar radiations
(Lin, 2009)	Thermal acceptability range in Taiwan is higher than in Western/ Middle Europe
(Lam, 2011)	People prefer higher values on climatic factors of OTC assessments namely temperatures, wind & relative humidity.
(Lin et al., 2012)	People's presence correlated well with higher temperatures, & solar radiations in winter than in summer.
(Nasir et al., 2013)	People adapted to the climatic conditions for different activities they were indulged in.
(Lai et al., 2014)	Usage rate model correlated to thermal sensation votes showing people preferred warm temperatures.
(Chen et al., 2015)	People's presence is influenced by climatic factors: temperature & solar radiations and adaptative factors: duration of stay
(Klemm et al., 2015)	Perceived thermal comfort is affected by spatial environment perception such as green and water environments.
(Huang et al., 2016)	Optimum Thermal Environment (OTE) is introduced for Wuhan, that shows correlations with activity types, age and gender
(Li et al., 2016)	People adapt to outdoors through clothing, activity location (sunny vs shade) and activity times in different season
(Shooshtarian and Ridley, 2016)	Human factors namely gender, activity and skin color showed no relation whereas age-group, clothing insulation, activity location, peoples' company and cultural background showed strong relation to OTC levels.
(Melnikov et al., 2017)	Peoples' thermal adaptation was modeled through speed adaptation; thermal attraction/repulsion and vision motivated route alternation.
(Reinhart et al., 2017)	Predicted UTCI correlated well with the density of people & their dwell time. New method for data collection was used through Wi-Fi scanners and video camera.
(Vanos et al., 2017)	Gender based skin temperature showed varied metabolic rate levels. Actual thermal sensation values correlated very well with air temperature, solar radiations and tiredness levels as opposed to metabolic rate and RH.
(Yang et al., 2017)	People preferred high solar radiations & low winds in all seasons. Residents are more adaptive to climate than non-residents.
(Chokhachian et al., 2018)	Dynamic activities showed direct correlations to wind speed for transient comfort levels. Skin temperature did not correlate to UTCI.
(Galindo and Hermida, 2018)	Thermal sensation votes (TSV) showed weak relation to gender, age and skin tones but depicted strong correlations to clo-value and met levels.
(Gaspari et al., 2018)	Microclimatic study is influenced by the layout and green infrastructure on the site
(Hadianpour et al., 2018)	TSV, and PMV, PET or UTCI, correlated highest in spring & autumn, followed by summer, and least in winter.
(Li et al., 2018)	Preferred sun and wind conditions affected TSV and its corresponding UTCI values. Additionally, more sun and low winds correspond to cooler thermal sensation as against low sun and high winds at the same UTCI values.
(Santucci et al., 2018)	Variant sky view factor in urban morphology corresponds to higher microclimatic variations that affects pedestrian density.

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