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Biothermal conditions on Mt. Zlatibor based on thermophysiological indices

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Abstract: This paper presents part of the research in the field of human bioclimatology and refers to biothermal conditions in different geographical environments in Serbia: an urban area and a mountain of medium height. The goal of the paper was to show bioclimatic differences during the summer between the city of Belgrade (116 m a.s.l.) and the mountain resort of Zlatibor (1498 m a.s.l.). The basic principle of bioclimatic analysis is the human heat balance between man and environment. This methodological approach is a combination of physiological and meteorological parameters that result in thermophysiological bioclimatic indices: heat load (HL) in man and the Universal Thermal Climate Index (UTCI). For this analysis, weather data for July, as the warmest month, was obtained, using daily meteorological data for the decade from 2000 to 2010. Results for July indicate a considerable difference between the two abovementioned environments. HL in Belgrade was dominated by degrees of comfort "hot" and "extremely hot, with the highest value of 4.540, while for Zlatibor the dominant degree of comfort was "warm". The UTCI in Belgrade has dominated by strong heat stress and moderate heat stress, compared to Zlatibor where the UTCI is dominated by moderate heat stress. In addition, a significant part of the monitored decade on Mt. Zlatibor was without heat stress, with the exception of 2006 and 2007, indicating favorable biothermal characteristics. Therefore, compared to Belgrade, with its considerably lower overall heat stress Zlatibor has the characteristics of a site with favorable bioclimatic qualities.

Key words: human bioclimatology; human heat balance; heat load; universal thermal climate index (UTCI); recreation

INTRODUCTION

Human bioclimatology is a discipline that strives to understand the relationship between humans and the atmosphere. It has developed a number of approaches that can be used to demonstrate this relationship. One such approach is the human heat balance between man and environment, which is the basis for this paper. The intention was to try to identify potential geographical areas with favorable biothermal conditions in order to designate them as air spa resorts. In this process, health spa resorts are considered because they usually are places with a favorable climate and with healing air. Since they are located mainly in mountain valleys, their immediate surroundings are dense forests, lakes, rivers and caves, all very convenient for recreation. The goal of this paper was to use bioclimatic analysis to determine if Mts. Zlatibor in Serbia can be categorized as an air spa. We attempted to compare the biothermal conditions of the Zlatibor mountain resort with Belgrade, as the largest urban area in Serbia. Zlatibor (1028 m) is a mountain situated in the western part of Serbia, a part of the Dinaric Alps, and already confirmed as a climatic resort that is characterized by a cool mountain climate, clean air and long periods of sunshine during the summer, and snow in winter. The Zlatibor plateau is an area where mountains meet sea air currents, which, supposedly, creates a favorable climate for healing air, particularly for pulmonary, heart and thyroid diseases. Since Mt. Zlatibor is already established as a favorable climatic location, we considered the Belgrade urban area as a good example for comparison. The assumption was that Belgrade, as the largest urban area in Serbia, has specific bioclimatic conditions, such as an urban heat island with unfavorable conditions for recreation. Ex-

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isting heat waves should also be taken into consideration. According to Drljača [1], since the mid-1980s, the incidence of heat waves in Belgrade has increased and they occur on average every year, while before the 1980s, the average incidence of heat waves was once in every three years.

In the area of Belgrade, the influence of some meteorological parameters (temperature, solar radiation, relative humidity and wind speed) on ozone production and the daily profile of its ground level concentration has also been recognized [2].

Biothermal conditions are taken to be the response of the human body to thermal stimuli that shape the level of the actual heat load of an organism. To analyze biothermal conditions on Mt. Zlatibor, the HL index was used and then compared with the UTCI. HL in man is one of the thermophysiological bioclimatic indices based on human heat balance, derived from the MENEX (man-environment heat exchange) model [3,4,5]. The UTCI, based on the Fiala model, is one of the most advanced multi-node thermophysiological models [6,9].

MATERIALS AND METHODS

Thermophysiological bioclimatic index

The analysis was performed using the MENEX model, based on the human heat balance between man and environment [3,13]. This approach uses both meteorological and physiological parameters as input data in order to give the most complete bioclimatic conditions possible. The result (output data), presents the thermophysiological bioclimatic index of HL in man and demonstrates a considerable difference between the two mentioned investigated environments. HL results were compared with the UTCI [11]. For this calculation, daily meteorological data for July, as the warmest month, was taken from Mt. Zlatibor and Belgrade weather stations for the period 2000-2010. HL in man (nondimensional value) describes the load that the process of adapting to the environment presents to the central thermoregulatory system of a person. To calculate this, a combination of three main heat fluxes is used: total thermal accumulation (S), absorbed solar radiation (R), and heat loss through evaporation (E). The UTCI is based on the Fiala multi-node model [6,9,10], and includes the capability to predict whole-body thermal effects, such as hypothermia and hyperthermia, heat and cold discomfort, and local effects, i.e. the cooling of the face, hands and feet, and frostbite. [6] This scale is based on the intensity of objective physiological reactions to environmental heat stress in a wide range of weather conditions and climates.

Analysis of human heat balance

Analysis of the human heat balance between man and environment requires two types of data: meteorological data (air temperature, wind speed, air humidity, radiation, cloudiness) and physiological parameters (temperature of a person's skin, metabolic heat generation, insulation of clothes, albedo of clothes and the speed at which the person moves) [13]. For the purpose of calculating the indices of HL in man and the UTCI, average daily values of meteorological parameters in July for the decade from 2000 to 2010 were used. As a result, certain heat fluxes (such as absorbed solar radiation, convection, evaporation, breathing, long wave radiation) and thermophysiological bioclimatic indices of HL in man and the UTCI, were obtained. All calculations were performed using the "BioKlima 2.6©" software package. (http://www.igipz.pan.pl/geoekoklimat/blaz/BioKlima.htm).

RESULTS AND DISCUSSION

Results of daily values of heat load and the UTCI in Belgrade and on Mt. Zlatibor for the aforementioned period are presented applying the described bioclimatic methodology. Results refer to physiological parameters for a person with a metabolic heat of $135 Wm^{-2}$, dressed in a business suit and moving at a speed of $1.1\ ms^{-1}$.

Heat load indices in Belgrade are presented in Table 1 showing the presence of "extremely hot" and "hot" discomfort. The degree of comfort "warm" is also present, but to a lesser degree. When years are analyzed separately, it was noticeable that the years 2000, 2006, 2007 and 2008 each had over 15 days (more precisely, 16, 15 and 22 days, respectively) with the "extremely hot" HL. The greatest number of days with the HL "warm" was recorded in 2004 (eleven days). Other years

Table 1. Daily values of the human HL index in July, Belgrade (2000-2010).

day	HL_10	HL_09	HL_08	HL_07	HL_06	HL_05	HL_04	HL_03	HL_02	HL_01	HL_00	HL_sr
1	1.418	1.123	1.738	1.613	1.167	1.493	1.332	2.574	1.502	1.222	2. 27	1. 574
2	1.544	1.139	2.072	2.185	1.115	1.071	1.453	1.798	2.101	1.045	2.260	1.617
3	1.522	1.136	1.990	1.943	1.312	1.071	1.257	1.832	3.064	1.098	2.734	1.723
4	1.409	1.127	1.928	1.785	1.485	1.132	1.423	1.172	1.779	1.269	3.228	1.612
5	1.433	1.296	1.518	1.148	1.680	1.445	1.507	1.216	1.391	1.110	2.670	1.492
6	1.425	1.215	1.706	1.346	1.881	1.055	1.670	1.375	1.850	1.336	2.109	1.543
7	1.173	1.160	3.041	1.802	2.121	1.312	1.624	1.530	1.248	1.769	2.548	1.757
8	1.314	1.653	1.535	2.186	1.870	1.877	1.708	1.542	1.343	1.581	2.289	1.718
9	1.495	1.250	1.666	2.507	1.632	1.164	1.847	1.570	1.543	1.359	1.017	1.550
10	1.584	1.180	1.595	1.215	1.782	1.316	2.855	1.601	1.699	1.527	1.755	1.646
11	1.541	1.038	2.139	1.040	1.775	1.079	1.474	1.066	1.913	1.599	1.965	1.512
12	1.618	1.117	2.701	1.236	1.775	1.104	1.045	1.579	1.766	1.674	1.498	1.556
13	1.712	1.163	3.449	1.283	1.325	1.091	1.059	1.063	1.895	1.582	1.151	1.525
14	1.808	1.334	2.428	1.662	1.329	1.074	1.045	1.177	1.871	2.000	1.327	1.550
15	1.883	1.505	1.057	1.962	1.607	1.386	1.039	1.402	1.975	2.709	1.107	1.603
16	1.836	1.623	1.365	2.399	1.349	1.592	1.112	1.938	2.095	3.070	1.048	1.766
17	2.182	1.459	1.821	2.751	1.494	1.663	1.233	2.211	1.707	1.268	1.333	1.738
18	1.895	1.643	1.309	2.699	1.435	2.061	1.382	1.102	1.090	1.452	1.255	1.575
19	1.372	1.184	1.521	3.412	1.765	1.450	1.603	1.143	1.137	2.078	1.438	1.646
20	1.460	1.200	2.196	3.999	1.834	1.293	1.710	1.485	1.321	2.286	1.037	1.802
21	1.658	1.232	1.604	2.760	2.241	1.323	1.559	1.816	1.581	1.011	1.335	1.647
22	1.705	1.448	1.031	4.053	2.191	1.610	1.749	2.076	1.672	1.022	1.320	1.807
23	1.895	1.626	1.008	2.414	2.018	1.099	1.732	1.583	1.463	1.077	1.757	1.607
24	1.567	1.812	1.079	4.540	1.916	1.173	1.626	1.409	2.171	1.108	2.234	1.876
25	1.005	1.766	1.077	1.837	1.777	1.646	1.579	1.317	1.077	1.354	2.581	1.547
26	1.051	1.384	1.122	2.144	1.947	1.787	1.143	1.315	1.342	1.360	2.436	1.548
27	1.124	1.306	1.422	2.010	2.020	1.815	1.133	1.616	1.086	1.338	1.891	1.524
28	1.302	1.496	1.520	2.568	1.945	2.005	1.067	1.976	1.335	1.378	2.324	1.720
29	1.829	1.551	1.617	2.161	1.677	2.043	1.056	1.214	1.321	1.488	1.538	1.590
30	2.097	1.609	1.900	1.407	1.593	2.078	1.098	1.171	1.15l4	1.699	1.460	1.570
31	1.131	1.604	1.903	1.025	1.640	2.182	1.082	1.133	1.224	1.471	1.513	1.446

According to the HL index scale, degree of comfort is presented by different colors, as follows:

extremely hot	hot	warm	pleasant

had less than 10 days with this heat load. It should be noted that during the predominantly unfavorable HL period, there were 5 days with the HL "pleasant". The reason for this was a somewhat lower temperature and higher wind speed. When the mean daily values of the index for the abovementioned 11-year period were calculated, it became clear that the dominating HL was "hot", with 26 such days, whereas during the remaining 5 days the HL was "extremely hot".

Finally, mean monthly values of the index for the abovementioned period in Belgrade show a HL of "extremely hot" in 2000, 2006, 2007 and 2008, whereas other years show a HL of "hot". Mean monthly values of the index on Mt. Zlatibor show a combination of "hot" in 2000, 2002, 2004, 2006, 2007, 2008, and "warm" in 2001, 2005, 2009 and 2010 (Fig. 1).

Table 2 presents the HL index for Mt. Zlatibor and shows the domination of the more pleasant degree of comfort of "warm". To a lesser extent, a disagreeable degree of comfort is present in the years 2000, 2006 and 2007, when there were 6, 14 and 9 days, respectively, with a HL of "extremely hot" and 10, 15 and 11 days, respectively, with the HL "hot". In the remainder of this period, the HL "warm" was recorded. It should also be mentioned that there were 8 days in total with the HL "pleasant"; however, they were unevenly dis-

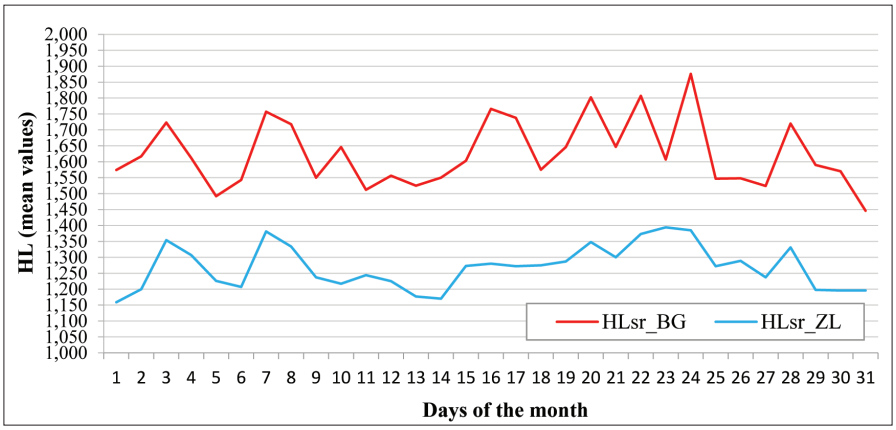

Fig. 1. Mean values of the HL index for the month of July during the period 2000-2010. The red line shows te mean value of the HL index in Belgrade (HLsr_BG); the blue line shows the mean value of the HL index on Mt. Zlatibor (HLsr_ZL). The more linear outline shows that the "hot" degree of comfort is higher in Belgrade than on Mt. Zlatibor, even with the average values of HL index for the given decade.

Table 2. Daily values of the human HL index in July, Mt. Zlatibor (2000-2010).

Day	HL_10	HL_09	HL_08	HL_07	HL_06	HL_05	HL_04	HL_03	HL_02	HL_01	HL_00	HL_sr
1	1.082	1.063	1.139	1.118	1.167	1.123	1.123	1.496	1.095	1.039	1.309	1.159
2	1.072	1.128	1.192	1.489	1.115	1.038	1.161	1.187	1.250	1.047	1.524	1.200
3	1.104	1.120	1.141	1.293	1.312	1.063	1.100	1.311	2.308	1.067	2.081	1.354
4	1.090	1.126	1.233	1.426	1.485	1.094	1.083	1.073	1.219	1.083	2.465	1.307
5	1.109	1.127	1.116	1.028	1.680	1.065	1.151	1.100	1.061	1.045	2.002	1.226
6	1.074	1.114	1.131	1.063	1.881	1.069	1.259	1.074	1.166	1.082	1.358	1.207
7	1.038	1.121	1.796	1.293	2.121	1.103	1.123	1.076	1.042	.1.513	1.968	1.381
8	1.048	1.139	1.130	1.295	1.870	1.103	1.580	1.011	1.112	1173	2.216	1.334
9	1.052	1.110	1.087	1.467	1.632	1.081	1.821	1.081	1.148	1.081	1.048	1.237
10	1.117	1.105	1.107	1.134	1.782	1.095	1.384	1.083	1.287	1.124	1.167	1.217
11	1.133	1.052	1.274	1.068	1.775	1.055	1.109	1.063	1.340	1.079	1.735	1.244
12	1.091	1.072	1.594	1.041	1.775	1.102	1.066	1.075	1.220	1.126	1.310	1.225
13	1.146	1.096	1.806	1.050	1.325	1.101	1.038	1.062	1.188	1.133	1.000	1.177
14	1.184	1.291	1.580	1.136	1.329	1.029	1.017	1.053	1.102	1.134	1.022	1.170
15	1.322	1.292	1.057	1.357	1.607	1.098	1.061	1.075	1.504	1.598	1.035	1.273
16	1.316	1.175	1.060	1.451	1.349	1.106	1.096	1.225	1.465	1.740	1.095	1.280
17	1.203	1.175	1.138	1.983	1.494	1.107	1.134	1.441	1.081	1.176	1.063	1.272
18	1.125	1.490	1.123	1.939	1.435	1.327	1.273	1.104	1.089	1.078	1.038	1.275
19	1.131	1.070	1.112	1.921	1.765	1.295	1.295	1.114	1.106	1.266	1.086	1.287
20	1.111	1.083	1.327	1.989	1.834	1.076	1.362	1.125	1.082	1.810	1.027	1.348
21	1.095	1.097	1.122	1.989	2.241	1.083	1.306	1.215	1.129	0.997	1.028	1.300
22	1.185	1.334	1.027	2.444	2.191	1.063	1.195	1.463	1.099	1.043	1.064	1.373
23	1.411	1.719	1.014	2.081	2.018	1.077	1.343	1.306	1.082	1.037	1.243	1.394
24	1.084	1.417	1.053	2.592	1.916	1.112	1.105	1.125	1.287	1.053	1. 494	1.385
25	1.045	1.191	1.105	1.093	1.777	1.102	1.125	1.141	1.099	1 098	2. 218	1.272
26	1.064	1.062	1.080	1.317	1.947	1.338	1.127	1.078	1.080	1.081	2. 000	1. 289
27	1.070	1.063	1.132	1.445	2.020	1.280	1.078	1.161	1.073	1.057	1.224	1. 237
28	1.073	1.279	1.110	1.886	1.945	1.337	1.025	1.358	1.064	1.128	1.435	1. 331
29	1.096	1.152	1.106	1.394	1.677	1.330	1.024	1.103	1.121	1.107	1.072	1.198
30	1.241	1.168	1.171	1.071	1.593	1.452	1.074	1.085	1.094	1.089	1.115	1.196
31	1.104	1.136	1.174	1.056	1.640	1.592	1.072	1.088	1.090	1.091	1.109	1.196

According to the HL index scale, degree of comfort is presented by different colors, as follows:

extremely hot	hot	warm	pleasant

Table 3. Daily values of UTCI in July, Belgrade (2000-2010).

Day	UTCI00	UTCI01	UTCI02	UTCI03	UTCI04	UTCI05	UTCI06	UTCI07	UTCI08	UTCI09	UTCI10	UTCIsr
1	27.4	25.7	29.8	35	26.2	28.7	30. 0	30. 2	3. 7	29. 8	32. 0	27.2
7	31.7	21.5	28.9	30.1	32.2	20.4	25.5	32.4	3. 3	31. 8	32. 7	27
3	32.8	27.5	32.5	30.8	20.4	24.4	20.1	30.5	3. 3	30. 8	22. 4	25.5
4	37.9	27.8	27.9	23.7	25.2	25.9	22.6	26.2	29 0	26. 7	29. 9	25.6
5	32.3	28	28.7	24.1	30.3	28	28.7	23.7	266	30. 3	27. 1	26.1
6	29.1	28.8	32.8	23.9	28.5	20.5	29	25.3	27	31. 9	27. 5	25.9
7	31.8	26.3	26.6	25.7	29	26.6	29.3	27.9	33.8	26. 6	21. 3	26
8	30.9	32.6	31	23.6	31.6	28.4	29.5	32.2	27.6	28. 8	26. 0	27.5
9	16.4	29.3	32.2	25.6	34.5	25.8	29.3	33	24.7	26. 3	30. 5	26.4
10	24.9	31.6	35	25.1	29.6	28.7	31.7	23.6	29.1	27. 4	32. 3	27.4
11	26.5	30.3	36.5	23.6	27.9	25.6	31.5	21	31.5	22. 8	33. 2	26.8
12	24.3	30.9	31.2	27.8	20.5	25.2	31.9	22.6	31.8	23. 0	33. 9	26.3
13	14.4	33.3	34.8	23.6	22.2	24.4	27.8	25.2	34	27. 1	35. 0	26.2
14	20.1	31.9	32	23.4	15.3	25	28.6	29.9	28	33. 1	35. 8	26.4
15	18.6	30.9	33.9	26.7	17.3	27.7	26.3	33.7	20.9	34. 2	36. 5	26.8
16	17.3	32.8	34.6	30.3	21.5	29.8	23.5	34.5	25.6	34. 9	36. 9	28.1
17	21.8	25.5	31.8	31.8	26.1	30.1	24.6	35.7	29.7	33. 0	33. 3	28.4
18	23.2	26.1	25.5	25.8	28	33.6	28.7	36.5	26.7	28. 6	28. 8	27.5
19	23.2	28.3	26.9	30.6	29.1	27.5	29.5	37.4	28.2	24. 2	29. 7	27.8
20	21	29.5	28.5	32.4	29	24.8	32.5	36.8	31.1	25. 5	34. 7	28.8
21	20.6	17.8	29.3	34	30.6	26.5	31.2	37.7	27.1	30. 9	35. 3	28.5
22	24.3	18.2	26.4	35.2	32.4	28	32.4	39.1	19.5	29. 8	35. 5	28.6
23	30.1	24.6	26.6	31.2	32.2	24	33.6	33.5	16.5	35. 0	32. 9	28.6
24	31	20.6	29.9	28.8	26.1	29.2	33.6	36.1	25.6	34. 0	25. 2	28.7
25	33.8	24.5	24.3	29.2	26.7	28.5	32.2	25.4	24.6	25. 8	15. 2	26.3
26	34	24.9	26	31.3	27.1	33	33	28.3	28.9	25. 7	23. 1	28.4
27	29.2	28.9	25.2	32.2	28.2	34.6	33.5	32	28.3	28. 2	23. 8	29.2
28	29.7	29.2	26	32.5	23.2	35.8	33.4	32	29.9	31. 7	30. 4	30.1
29	22	32.3	30.4	28.4	22.5	31.8	31.6	31.9	30.5	31. 2	24. 5	28.8
30	26.8	27	31.2	19.4	21.4	32.8	30.3	20.2	31.4	31. 5	29. 3	27.6
31	22.9	32.1	29.8	26.9	21.8	35.1	32.6	19.8	33.4	32. 4		28.9

Different colors indicate stress category relating to UTCI index, as foolows:

strong heat stress	moderate heat stress	no thermal stress

tributed. When it comes to the main daily values of the index for observed period of eleven years, the domination of the HL "hot" is noticeable, with an exception of three days with the HL "warm".

Table 3 presents daily values for the UTCI for July in Belgrade. As expected, in Belgrade strong heat stress and moderate heat stress dominate. There were periods also in this decade when no thermal stress was observed. Only one day in 2007 had very strong heat stress.

As also expected, compared to Belgrade urban area and due to its elevation and different geographical environment, Mt. Zlatibor has pleasant biothermal conditions. This is evident in Table 4, which shows no dominant heat stress for this decade. There were periods with moderate heat stress uniformly distributed in the month of July throughout the investigated decade. There was one day with strong heat stress in 2009 and one with slight cold stress in 2001.

For the last twenty years of bioclimatic research, researchers have been concentrating on studying the direct relationship between the atmosphere and the human body. This bioclimatic research is based on the human heat balance between man and environment. Human heat balance models allow considera-

Table 4. Daily values of UTCI in July, Mt. Zlatibor (2000-2010).

day	UTCI00	UTCI01	UTCI02	UTCI03	UTCI04	UTCI05	UTCI06	UTCI07	UTCI08	UTCI09	UTCI10	UTCIsr
1	23.2	19.7	25	25. 4	25	27.6	25.8	27. 4	28.8	20.3	23	22.7
7	27.2	20.3	27.7	28. 8	27.9	16.7	25.5	25. 3	28.9	27.7	22.2	23.8
3	30.9	23.2	24.5	27. 3	24.8	20.3	16.4	26. 4	28.1	26.9	26.3	23.2
4	28.3	25.4	22.8	22. 3	24.4	24.3	17.5	23. 5	23.7	27.1	24.4	22.3
5	29.3	21.3	21.6	24. 7	27.7	21.9	22.4	16. 3	26.5	27.9	24.2	22.4
6	28.4	25.8	29.3	23. 1	29.4	21.3	27.3	22. 0	25.3	26.9	22.6	24
7	26.7	26.9	18.2	23. 3	27.2	25.5	25.3	24. 9	27.9	27.2	18.6	23.2
8	26.6	28.1	26.4	15. 9	29.7	26	26.8	29. 1	27.9	23.5	19.2	23.9
9	18.7	25.7	29.6	20. 2	28.4	23.5	26.7	30. 3	24.6	25.8	20.2	23.6
10	22.8	28.7	28.9	24. 2	28.3	24.5	25	24. 0	27	25.9	26.9	24.7
11	19.4	24.1	29	21. 4	26.2	19.5	25.6	20. 7	26.8	18.7	28.3	22.6
12	19	29.4	29.4	23. 8	20.6	24.9	28.2	18. 7	26.9	22.4	24	23.3
13	11.2	30	24.1	21. 4	17.3	24.6	25.3	21. 1	28.9	25.7	29.6	22.7
14	17.2	30	25.6	20. 2	14.7	15.5	27.1	22. 1	26.3	28.3	28.3	22.4
15	16.1	27.9	28.7	23. 5	20.9	25.2	20.8	25. 7	20.2	30	28.6	23.6
16	23.4	25.5	22.1	27. 5	25.1	26	22.6	31. 3	21	31.7	29.7	25.2
17	21.7	16.9	23.6	28. 9	23.2	26.5	23.8	31. 0	25.6	30.5	30.5	24.9
18	18.5	25.1	23.8	25. 8	26.2	25.3	22.5	32. 4	27.7	26.5	27.5	24.9
19	23.3	26.3	25.7	26. 1	28	23.2	24.8	31. 6	26.4	22.3	27.9	25.4
20	16.1	22	23.6	28. 0	28.8	23.5	28.5	31. 8	27.5	24.6	26.3	25.1
21	16.7	6.5	25.8	30. 1	30.7	24.2	29.2	31. 6	28.1	26.2	24.5	24.5
22	22.2	19.4	25.9	27. 7	31.3	21.1	29.3	31. 3	14.8	27.9	29.2	25.2
23	23	18.8	24.6	28. 3	28.5	22	29.1	30. 4	12.7	28.2	28.8	24.8
24	25.2	20.8	25.4	25. 6	26.3	26.1	27.9	29. 8	19	32.5	23.8	25.5
25	24.3	26.7	24.3	29. 1	27.7	26	26.9	25. 7	25	27.6	17.9	25.5
26	24.9	24.8	22.9	22. 9	27.3	27.7	28.8	24. 0	22.3	22	20.5	24.5
27	29.2	22.5	21.6	25. 8	22.1	30.3	26.4	27. 9	27.1	22.9	21.8	25.4
28	27.5	19	20.6	30. 0	14.8	31.5	27.9	29. 4	26.3	27	22.3	25.3
29	22.6	22.3	26.7	25. 4	14.5	29.8	25.5	29. 3	26.1	28	25.6	25.4
30	26.5	26	24.3	23. 6	22	30.2	26.5	23. 0	27	28.1	27.2	26.2
31	25.7	26.6	24	23. 9	21.7	30.2	24.7	19. 5	28.9	28.9	25. 0	25.8

Different colors indicate stress category relating to UTCI index, as follows:

strong heat stress	moderate heat stress	no thermal stress	slight cold stress

tion of both the effects of heat exchange with the atmosphere (stress) and the physiological response (strain). Thus, we presented results of the thermo-physiological indices HL in man and the UTCI. Both indices are calculated for Belgrade urban area and Mt. Zlatibor in order to demonstrate the difference in bioclimatic conditions. Bioclimatic conditions in Belgrade are clearly unpleasant, with the dominant HLs of "extremely hot" and "hot". The situation on Mt. Zlatibor is somewhat more favorable, since the dominant HL is "warm". The heat loads "extremely hot" and "hot" are also present there, but to a lesser degree in comparison to Belgrade. The results for the UTCI also show unpleasant bioclimatic conditions in Belgrade, with a domination of strong heat stress and moderate heat stress compared to Mt. Zlatibor, where no heat stress dominates.

Comparison of bioclimatic conditions on Mt. Zlatibor and in Belgrade remind us of the specific climatic conditions in urbanized areas with no conditions for recreation. These are separate climate entities, such as the urban heat island, reduction of

wind and large spatial differences in solar radiation penetrating to the bottoms of street canyons. As can be observed, the indices represent relevant information about the influence of climate on humans. They can be used for identifying criteria for the presence of adequate, acceptable or unacceptable conditions for recreation in health and recreation centers, spas and health resorts.

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