Original Article

Comparing and evaluating microbial and physicochemical parameters of water quality in men's and women's public swimming pools in Kermanshah, Iran: A case study

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ABSTRACT

Amis: The present study was aimed to compare and evaluate the level of microbial (parasitic and bacterial) quality and physicochemical conditions of the water from five different types of indoor swimming pools (three men's and two women's pools).
Materials and Method: This research was a cross-sectional study. Totally, 60 water samples were collected from five public swimming pools in Kermanshah, Iran. Microbial (parasitec and bacterial) and physicochemical conditions were examined according to the standard method.
Results: Results indicated that the average of physicochemical parameters, except temperature, in all women's swimming pools was more sufficient than the men's swimming pools; but, there was no significant difference between them ($P > 0.05$).
Conclusion: It can be said that, gender cannot be very effective (especially, in terms of physiological characteristics of skin) in varying physicochemical conditions and biological parameters in swimming pools. The main reason for changing these parameters might be attributed to some factors, such as type and extent of relationship between physicochemical and biological parameters, characteristics and source of water, type of filtration system, pools' operation and maintenance, effective disinfection, personal hygiene, etc.

Key words: Kermanshah, public swimming pools, water quality

INTRODUCTION

Most people from various classes attend swimming pools as one of the most beneficial forms of exercise in the world; however, poor personal hygiene of swimming pool users can cause various illness in public pools and expose bathers to diseases. The risk of various diseases related to swimming in pools has been associated with contaminated water due to body shedding of bathers includes body fluids such as urine, blood, saliva or vomit, hair, release of respiratory, digestive, and genital bacteria, and other harmful bacteria from skin.[1,2] Nowadays, swimming in public pools has been recognized as one of the most important illness or infection transmission channel in the world.[3] So, evaluation physicochemical condition along with bacterial and parasitic parameters is significant in water pools, and desirability or undesirability of these parameters is very effective in the health of bathers and staff. Some physical and chemical

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factors which may contribute to the spread of skin illness in the pools include adjusted pH, chlorine residual, turbidity, and temperature, which are very important in describing the microbial quality of pool water, because these parameters can affect biological factors or neutralize each other. Whenever these parameters are not in the normal range, microbial quality in the water of swimming pools is made undesirable. For example, if the pool's water temperature rises to >27°C, the activity of microorganisms within swimming pools will increase compared with that of other swimming pools in the range of 22-27°C.[4] However, assessment of microbial parameters in pool water about their role in various diseases such a external otitis by *Pseudomonas aeruginosa* is an important issue.[5] Recently, factors such as *Escherichia coli* are recognized as the best indicators for monitoring pools' water contamination.[6] However, some other studies have known *E. coli* coliforms, total coliforms, and heterotrophic bacteria as the best indicators for the evaluation of pool water.[7] According to World Health Organization, the microorganisms which are used for the evaluation of microbial conditions in swimming pools and similar environment are heterotrophic bacteria plate count (HPC), fecal indicators (such as, total coliforms and *E. coli*), *P. aeruginosa*, *Staphylococcus aurous*, and *Legionella*. Also, both fecal and nonfecal indicators should be determined to assess the health risks of swimming pools and similar environments. However, stool test, HPC, *S. aureus*, *P. aeruginosa*, and *Legionella* analysis are used for testing the presence of fecal and nonfecal indicators, respectively.[8]

According to the available few studies on the comparison of water quality of men's and women's public swimming pools and lack of current information in terms of the amount and type of pathogenic microorganisms and physicochemical conditions influencing public swimming pools in Kermanshah according to to the recent standards, the present study was aimed to compare and evaluate the level of microbial (parasitic and bacterial) quality and physicochemical conditions of water from five different types of indoor swimming pools (three men's and two women's pools) during summer season in Kermanshah, Iran, and compare the obtained results with the national standard. Therefore, if the samples did not met the national standard of microbial quality in swimming pools, a number of procedures should be followed to improve the pools' water quality in order to prevent the transmission of communicable diseases.

MATERIALS AND METHODS

The study was a laboratory-based cross-sectional study. Totally, 5 public swimming pools (3 men's and 2 women's pools) from the pools with the majority of attendances were selected in the summer season. A week (4 days of a week including 2 weekend days of Thursday and Friday with the highest swimming users and 2 working days with the highest and lowest swimming users) of each month was randomly selected in summer season sampling and totally 60 samples (12 samples from each pool) were collected for analysis according to standard methods. The parameters included temperature and turbidity (turbidity meter portable device, Loribond, from Japan), free chlorine level, and pH value (Amkor [DPD], purchased from Germany) and parasitic and bacterial quality of all the samples was analyzed. All the sampling and analysis were carried out according to the standard water and wastewater experiments and the approved guidelines for microbial quality assessment of swimming pool water which have been published by Institute of Standards and Industrial Research of Iran. Thus, HPC bacteria, count of total coliform and *E. coli*, intestinal enterococci, and *P. aeruginosa* were found to be 5271, 3759, 3620, and 8869, respectively, using national standard methods.[9-12] The parasitic quality and *S. aurous* were measured (microscope, Nikon model, and centrifuge Hettich model purchased from Japan) according to the methods approved by Institute of Standards and Industrial Research of Iran.[11-14]

Statistical analysis

For data analysis, comparison of the parameters in men's and women's swimming pools was carried out by Mann–Whitney U-test at $\alpha = 0.05$. Total characteristics of the five investigated swimming pools in Kermanshah are presented in Table 1.

RESULTS

The obtained results of physicochemical, parasitic, and bacterial parameters compared with maximum limited standard are presented in Tables 2 and 3. Table 4 shows the proper percentage of the mentioned parameters in 5 investigated swimming pools.

DISCUSSION

These results confirmed that the desirable total percentage of physicochemical parameters, except the temperature, in women's swimming pools was better than the men's; however, this difference was not significant ($P > 0.05$).

Average desirability of free chlorine level, temperature, turbidity, and pH of 70% ± 34.6%, 70% ± 10%, 26.6% ± 11.5%, and 90% ± 17.3% were obtained in men's pools, respectively. This finding was in line with the findings by Rasti *et al*.[18] who found the desirability of free chlorine level and pH value of 71 and 88%, respectively. Also, Alamdar *et al*.[17] showed that the desirability of free chlorine level and pH value in the categories of swimming pools was 57.8 and 77%, respectively, while the results of 25 and 22.8% of desirable free chlorine level in the categories of swimming pools were obtained by Barikbin *et al*.[19] and Jaberi *et al*.,[20] respectively. Thereby, differences of desirability in water quality due to physicochemical parameters in the present study from

Table 1: Characteristics of the five investigated swimming pools in Kermansha

Swimming pools	Dimension			Standard length/ width	Area (m^2)	Average of swimming pool users in any time	Area (m^2/ bather)	Standard area (m^2/bather)	Disinfection system	Water supply	Treatment system
	Length (m)	Width (m)	Length/ width								
Man											
A	33	14	2/36	2-5	462	100	4.62	3	Chlorination	Well	Sand filter
C	20	10	2		200	110	1.81		Chlorination	Well	Sand filter
B	50	25	2		1250	200	6.25		Chlorination	Well	Sand filter
Woman											
B	21.5	10	2.15		215	70	3.07		Chlorination	Well	Sand filter
A	25	12	2.08		300	80	3.75		Chlorination	well	Sand filter

Table 2: Mean value of physicochemical, parasitic and bacterial parameters in water samples from the five investigated swimming pools in compare with maximum limited of national standard

Parameters	N/100 ml	Man pools			Woman pools		Maximum limited
		A	B	C	A	B	
Total coliform	MPN/100 mL	8	9	25	7	11	460
Escherichia coli	MPN/100 mL	0	0	5	0	0	<1
Pseudomonas aeruginosa	MPN/100 mL	0	2	8	12	0	<1
Staphylococcus aurous	MPN/100 mL	4	1	3	1	0.4	50
Intestinal enterococci	MPN/100 mL	0	0	13	0	0.1	100
HPC	cfu/mL	135	91	79	47	25	200
Parasitic quality	MPN/100 mL	0.3	0	0	0	0	0
Turbidity	NTU	1	1	1	1	0.79	0.5
Free chlorine level	mg/L	1	1	0.5	1	1.1	1-3
pH	—	6.8	7	7	7	6.6	6-8
Temperature	°C	28	28	28	28.6	28	23-28

HPC: Heterotrophic bacteria plate count

Table 3: Range of physicochemical, microbial parameters in water samples from the five swimming pool categories in compare with maximum limited of national standard

Parameters	Unit	Man pools			Woman pools		Maximumlimited
		A	B	C	A	B	
Total coliform	MPN/100 mL	8±1	9±1.5	24±2.8	7±0.5	11±2.5	460
Escherichia coli	MPN/100 mL	0	0	5±1	0	0	<1
Pseudomonas aeruginosa	MPN/100 mL	0	2±0.5	8±4	12±2	0	<1
Staphylococcus aurous	MPN/100 mL	0.4±0.5	1±0	3±0.6	1±0	4±1.5	50
Intestinal enterococci	MPN/100 mL	0	0	13±4.5	0	0.1	100
HPC	cfu/mL	135±28	91±18.8	79±27.6	47±8.5	25±6.6	200
Parasitic quality	MPN/100 mL	0.3	0	0	0	0	0
Turbidity	NTU	1±0.8	1±0.7	1±0.2	1±0.3	0.79	0.5
Free chlorine level	mg/L	1±0.4	1±1.1	0.5±0.7	1±0	1.1±0.9	1-3
pH	—	6.8±0.2	7±0.2	7±0.1	7±0.2	7±0.4	6-8
Temperature	°C	28±0.6	28±1	28±0.5	28.6±0.5	28±1	23-28

HPC: Heterotrophic bacteria plate count

previous studies could be due to the differences in operation and maintenance by treatment plant operators, especially in terms of chlorination, inlet water characteristics in the base of turbidity, and other factors.[15,16,21,22]

Available area range (m^3/each bather) of all the investigated pools in the present study was respectively as follows: B men's pool > A men's pool > A women's pool > B women's pool > C men's pool. In comparison, the numbers of women bathers were more than those of men since the number of woman bathers regularly using Zarrin and Pasargad swimming pools were higher than man in terms of frequency. Thus, moe area was obtained for each man than woman bather. Among the five investigated pools, the lowest area for each bather was observed in the C men's pool, which was less than the standard level (2-5 m^2/each bather).[15,16] So, C men's pool was more contaminated than other 5 ones (4 pools with an area of each swimming user within the standard level) and involved low water quality in terms of some biological parameters. Nanbakhesh *et al*.[23] work on parasitic contamination and physical and chemical characteristics of indoor pools in city of Urmia demonstrated that, in the pools with less volume of water relative to the number of bathers, parasitic contamination was higher. The result of bacterial analysis in the present study indicated that no total coliform and *S. aurous* were isolated in both men's and women's pool categories (100% desirability). However, water quality of women's pools were more sufficient than that of men's according to other selected indicators including intestinal enterococci, *E. coli*, *P. aeruginosa*, HPC, and parasitic quality; also, due to the mentioned parameters, significant differences were found between men's and women's pool

Table 4: Percentage of desirable and undesirable samples due to physicochemical, parasitic and bacterial parameters in the five swimming pool categories in summer season

Swimming pools	Sampling	Desirable (%)										
		Free chlorine level	pH	Temperature (°C)	Turbidity	Total coliform	*Escherichia coli*	*Pseudomonas aeruginosa*	Staphylococcs aurous	Intestinal enterococci	HPC	Parasiticquality
Man												
A	10	90	70	80	20	100	100	100	100	100	80	70
B	10	90	100	60	20	100	100	50	100	100	100	90
C	10	30	100	70	40	100	80	50	100	90	80	90
Mean	—	70±34.6	90±17.3	70±10	26.6±11.5	100±0	93.3±11.5	66.7±28.9	100±0	96.8±5.8	86.7±11.5	83.3±11.5
Woman												
A	10	80	100	40	30	100	100	80	100	100	100	80
B	10	80	100	40	30	100	100	100	100	100	100	100
Mean	—	80±0	100±0	40±0	30±0	100±0	100±0	90±14.1	100±0	100±0	100±0	90±14.1

categories ($P > 0.05$); but, there was no significant difference ($P > 0.05$) in terms of intestinal enterococci and parasitic quality. Indeed, the bacterial and parasitic qualities of women's pools were lower than those of men's. So, there was a positive relationship between the levels of microbial parameters and physicochemical conditions.[21,22] It was shown that the swimming pools with particular desirability of physicochemical parameters (especially, free chlorine level) had a sufficient condition in terms of microbial quality. It can be said that high turbidity could protect microorganisms against disinfection and also increase water's chlorination requisite. Accordingly, the desirability of pools' water quality in terms of free chlorine level confirmed the lack of microorganisms (except resistant microbial to chlorination).[4,21,22] So, preserving physicochemical parameters within the standard range is one of the most important factors for preventing the microbial contamination of swimming pools. Additionally, due to resistant parasites to disinfectants, the desirability of physicochemical conditions within the standard level could not be very effective in the removal of parasites.[24] So, high performance of treatment systems (especially functioning filters) is required to improve water quality regarding these two parasitic parameters,[15,16] which was similar to the results for Rabi *et al*.[25] Obtained data of the present research showed that physicochemical parameters (free chlorine level) could prevent the prevalence of diseases by pathogenic microorganisms. However, some microorganisms are more resistant to disinfectants; thereby, functioning filters should be applied to remove resistant microorganisms, which is in consistency with Martin's[26] study who found that the free chlorine level was very effective for the control of all selected microorganisms (total coliform, *E. coli*, *S. aurous*, *P. aeruginosa*, fecal streptococci, and HPC). Also, Dingman[27] showed that disinfection is very effective in the removal of problematic microorganisms such as coliform and *P. aeruginosa* from swimming pools. Despite the low physicochemical parameters in the B women's pools, the microbial and parasitic qualities were desirable, which could be due to proper management in order to monitor the principle of personal hygiene, especially preswimming bath or performance of filtration system in B women's pool rather than B men's pool.[28-30]

Studies in different areas have reported variable results. The obtained results of this study were in line with those of some studies carried out by Lotfi *et al*.[19] and Barikbein *et al*.[19] who showed that there were no *E. coli* in all the analysis samples. Also, another study by Karegar *et al*.[32] indicated that the microbial contamination of analyzed samples was in the standard range. Additionally, the results of the present study were not consistent with some other studies including Alamdar *et al*.[17] who showed that 8.8% of the samples were contaminated with bacteria. Mehdinejad[2] indicated that 25% of the samples were contaminated with fecal coloiforms. Hajjartabar M *et al*.[33] demonstrated that 63.3 and 18.6% of the investigated pools were contaminated with *P. aeruginosa*

and total coli form, *E. coli*, and HPC, respectively. The study by Lika *et al*.[34] revealed that total coliform, *E. coli*, and fecal *Staphylococcus* of the analyzed samples were more than the limited standard. Rigas *et al*.[35] showed in Greece that the percentage of the samples inconsistent with the microbial standards was variable from 45% to 91%; also, *P. aeruginosa* and S. *aurous* were the most common bacteria in the swimming pools.

CONCLUSION

In summary, according to the above points, gender (in terms of physiological characteristics of body skin) cannot be very effective in the variable of the physicochemical parameters in swimming pools. However, main issues in varying these parameters could be due to the relationship between physicochemical and microbial parameters, characteristics of inlet water, source of water supply, operation and maintenance of pools, effective disinfection, personal hygiene, especially preswimming bathing, etc.[4,15,16] In addition, preserving physicochemical parameters within the standard level is required considering the important role of these parameters (especially, turbidity and temperature) in the function of chlorination against microorganisms and also effect of these parameters in providing suitable conditions for microorganisms. Also, achieving a proportion in the number of swimming pool users and the area and volume of pools could be helpful in reducing water contamination. Considering the existence of parasites and *P. aeruginosa* in most of the pools, it is necessary to take effective measures for promoting filtration system and disinfection in swimming pools.

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