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Measurement of Students' Personal Space and Designing a University Library Seating Layout in the Faculty of Public Health, Zanjan University of Medical Science (2024)

Seyed Reza Azimi Pirsaraei [a], **Reza Kalantari** [a*], **Niloofar Shabani Arbusara** [a], **Amir Reza Abidi** [a], **Parsa Fooladi** [a]

a. Department of Occupational Health Engineering, School of Public Health, Zanjan University of Medical Sciences, Zanjan, Iran.

***Corresponding author:** Department of Occupational Health Engineering, School of Public Health, Zanjan University of Medical Sciences, Zanjan, Iran. Postal Code: 4515786349. E-mail: dr.r.kalantari@zums.ac.ir

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ABSTRACT

Background: In educational settings, violations of personal space may influence students' learning performance. Designing seating layouts considering personal space dimensions enhances students' learning efficacy and concentration. This study aimed to measure students' personal space and presenting a design for the university library seating layout.

Methods: This cross-sectional study was conducted in 2024 among 224 students in the faculty of public health, Zanjan University of Medical Sciences, Iran. Data on demographic characteristics were collected using a structured demographics questionnaire and personal space size was measured through the Stop-Distance procedure. Measurements were taken using active and passive trials, with confederates of both genders approaching participants from eight main directions. Data were analyzed using SPSS version 24, applying descriptive statistics, Pearson correlation coefficient, and one-way ANOVA.

Results: The students maintained shorter distances when interacting with individuals of the same gender compared to those of the opposite gender. They also exhibited greater distances toward confederates approaching from the south and southeast orientations (*P-value* < 0.05). Based on the 95th percentile of measured distances, a revised seats layout was proposed to provide students with more adequate space.

Conclusion: The students exhibit distinct patterns in the size and orientation of their personal space. A library seats layout tailored to students' personal space requirements can create a more comfortable study environment, ultimately enhancing their academic experience.

1. Introduction

The study of human personal space began in the mid-20th century, initially within the field of social psychology. This concept was first explored as essential for maintaining body integrity and serving defensive purposes (Sommer & Iachini, 2017). Personal space is defined as a comfort zone surrounding the human body that is typically kept free from intrusions by others to ensure a sense of safety and protect against harm (Hayduk, 1981). It is considered a portable territory, either temporary or permanent, that functions as the boundary for social interactions (Pheasant & Haslegrave, 2018). When interacting with others, individuals generally prefer others to maintain a comfortable distance and respect their personal space (Hecht et al., 2019). Research has shown that intrusions into personal space, such as those experienced by train passengers, are associated with increased cortisol levels and discomfort (Evans & Wener, 2007). Consequently, studying and measuring personal space is crucial. Personal space-viewed as hidden

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dimensions of the body-should be factored into interactions between humans, their environments, and others (Panero & Zelnik, 1979). Studies on personal space have been conducted in various contexts, and the findings have been applied in design, education, and legal frameworks (Sommer, 2002). Several methods are available for measuring personal space. Among these, the naturalistic method is considered the most reliable. In this approach, human interactions are experimentally arranged, often involving confederates who approach subjects. This method minimizes uncontrolled variables. The role-playing method, widely used in many studies, involves asking subjects to indicate when they feel uncomfortable as another person approaches. Body boundaries are measured by approaching subjects from different angles. However, the awareness of being observed and the lack of spontaneity may influence the results. Paper-and-pencil techniques are often adaptations of the role-playing method or utilize the Comfortable Interpersonal Distance Scale (CID). In these techniques, participants are presented with a diagram of a room and asked to imagine themselves at the center. They mark stop points on the diagram as approaching figures encroach from eight different directions. These marked distances are then used to determine personal space dimensions (Slane et al., 1981).

In 1966, Hall proposed four spatial distance ranges: intimate space (0-45 cm), personal space (45-120 cm), social space (120-365 cm), and public space (365-752 cm), based on sensory perceptions (Hall, 1966). Several factors influence personal space dimensions (Holt et al., 2015; Kennedy & Adolphs, 2014; Uzzell & Horne, 2006). Personal space varies across cultures; for example, a study revealed that Latinos and Mediterranean people tend to have smaller personal spaces compared to Asians and Anglo-Saxons (Beaulieu, 2004). Personal space decreases when individuals share common interests or collaborate, while it increases with factors such as illness, anxiety, and smoking (Hayduk, 1983). The significance of personal space has grown since the introduction of social distancing guidelines to prevent the spread of COVID-19. During the pandemic, personal space increased from 78.8 cm to 124.5 cm in active trials and from 62 cm to 99 cm in passive trials (Holt et al., 2022). Even though the pandemic has ended, its effects likely continue to influence perceptions of personal space. For instance, one study reported personal space among students to range from 83-95 cm (Welsch et al., 2019). Nishihara & Okubo (2015) found that women tend to maintain larger distances from men, while men generally maintain shorter distances from women. Welsch et al. (2019) observed that personal space is typically circular, with shorter distances between women and greater distances maintained between men.

In educational settings, personal space is crucial as it can impact learning and performance (Azemati et al., 2018). A lack of personal space may distract some individuals while studying. A recent study on personal space in an educational setting showed that non-native students have larger persona space size (Azimi Pirsaraei et al., 2025). Personal space can act as both a physical and mental barrier, promoting focus, calmness, and productivity (Keser & Küçük, 2021). Designing educational environments that consider students' mental and physical characteristics can foster better social behavior and academic engagement. For example, U-shaped seating arrangements help students maintain their personal space while encouraging interaction and engagement in the classroom (Esmaeili et al., 2019). The multicultural composition of universities and the varying personal space preferences across cultures underscore the importance of measuring students' personal space (Lazarević et al., 2018). Despite its significance, research on personal space in educational environments is limited, particularly among university students. Furthermore, most existing literature dates back to the 20th century. The current generation of students has distinct characteristics and preferences. Although there is one study on Iranian students' personal space, it only compares native and non-native students and did not mention a practical guide for designing a proper library layout. It is while public spaces like libraries should be comfortable and have enough space for students. Adapting seating layouts to align with personal space dimensions can enhance students' learning and concentration. This study aims to measure personal space among students in the health faculty of Zanjan University of Medical Sciences and to propose an optimized library seating layout.

2. Materials and Methods

This cross-sectional study was conducted in the ergonomics laboratory at the Faculty of Public Health, Zanjan University of Medical Sciences, during the summer and autumn of 2024. The sole inclusion criterion was students' willingness to participate. The students with psychological disorders or visual impairments that could affect spatial perception were excluded. A census sampling method was employed. All 400 students in the faculty were invited via text messages and announcements, and 224 health major students agreed to participate (participation rate: 56%). Ph.D. students were excluded from the study as they do not use the library spaces and are provided with dedicated rooms at the university.

Data collection involved two methods. A demographics questionnaire gathered information on participants' age, gender, marital status, height, weight, hometown, and years of study at the university. Body Mass Index (BMI) was calculated using participants' height and weight. To measure personal space, the direct role-playing method was used. The "Stop Distance Procedure" (SDP), a validated and highly reliable method, was applied to determine personal space size (Hayduk, 1983). This method measures the distance at which the students first feel uncomfortable when another person approaches (passive) or when the subject approaches another person (active). Measurements were conducted during active and passive trials, with confederates of different genders approaching from eight main directions, where north represents facing direction, south represents approaching from behind, west represents left side of participants, and east represents right side of participants.

After obtaining approval from the ethics committee, the study environment was prepared. The ergonomics lab which was placed in the faculty was selected for its ample space. The place was cleared of unnecessary equipment. The rest of equipment were moved and arranged in the corner of the room to provide a comfortable and large space. The curtains were closed to control the windows effect. Eight 150-centimeter tape measures were fixed to the ground, radiating from the center of the lab in eight main directions. Questionnaires, informed consent forms, personal space measurement data sheets, and refreshments were prepared before each session. Subjects entered the lab one by one at a time after prior coordination. Researchers greeted each participant warmly, explained the study's purpose, and described the test structure. Subjects signed the informed consent form and completed the demographics questionnaire. The confederates were two normal looking master of sciences students studying in the faculty of public health. They were 23 years old, 162 cm and 175 cm of height for female and male confederates, respectively. They put same dress through the data collection sessions. They didn't use and perfumes. The order of trials was same for all of the students and was as passive with same gender, passive with different gender, active with same gender, and active with different gender. During passive measurements, the subject stood at the center of the circle while the confederate, maintaining a neutral facial expression, slowly approached from one of the eight main directions until the nearest distance that the participant felt comfortable. The participants said 'Okay' at the nearest distance that they were comfortable. The confederate maintained normal and not bothering eye contact during the trials that was same for all the participants. This procedure was conducted twice, using confederates of different genders. For active measurements, the subject approached the confederate from each of the eight directions. After completing the tests, the research team thanked the subjects and provided them with refreshments. The procedure was piloted on 30 subjects to ensure the method's reliability. A test-retest method was used to measure personal space sizes at two intervals, two weeks apart. Results showed a strong correlation between the two measurements (*P-value* < 0.001, r = 0.854).

Data were analyzed using SPSS version 24. Descriptive statistics were used to summarize demographic data and personal space sizes. Pearson correlation coefficients assessed relationships between personal space sizes (e.g., active versus passive sizes) and variables such as age, height, weight, and BMI. Independent sample t-tests and one-way ANOVA evaluated the relationships between demographic variables and personal space sizes. The 95th percentiles of personal space dimensions in each direction were used to develop a model for arranging library seating.

3. Results and Discussion

Out of 224 participants, 89 (39.7%) were male and 135 (60.3%) were female. Table 1 presents the demographics of the participants.

Table 1. Demographics of Participants

Variables	Description	Male participants	Female participants	Overall
Frequency	Number of participants	89 (39.7%)	135 (60.3%)	224 (100%)
Domesticity	Local	31 (34.8%)	66 (48.9%)	97 (43.3%)
	Non-local	58 (65.2%)	69 (51.1%)	127 (56.7%)
Degree	BSC	88 (98.8%)	133 (98.5%)	221 (98.7%)
	MSC	1 (1.2%)	2 (1.5%)	3 (1.3%)
Marital status	Single	87 (97.7%)	129 (95.5%)	216 (96.4%)
	Married	2 (2.3%)	6 (4.5%)	8 (3.6%)
Age (years)	Mean ± SD	21.20 ± 1.36	21.02 ± 1.75	21.09 ± 1.61
Height (Cm)	Mean ± SD	179.48 ± 5.63	163.59 ± 5.05	169.90 ± 9.41
Weight (Kg)	Mean ± SD	78.17 ± 14.05	59.63 ± 10.97	67.01 ± 15.26
BMI (Kg/Cm^2)	Mean ± SD	24.20 ± 3.72	22.22 ± 3.57	23.01 ± 3.75
Seniority	BSC 1st year	11 (12.4%)	45 (33%)	56 (25%)
	BSC 2nd year	43 (48.31%)	43 (31.85%)	86 (38.39%)
	BSC 3rd year	19 (21.3%)	29 (21.5%)	48 (21.42%)
	BSC 4th year	12 (13.5%)	16 (11.9%)	28 (12.50%)
	MSC 1st year	0 (0%)	1 (0.7%)	1 (0.4%)
	MSC 2nd year	1 (1.1%)	4 (2.9%)	5 (2.2%)

Tables 2 show the recorded personal space sizes in active trials (in centimeters).

Table 3 show the recorded personal space sizes in passive trials (in centimeters).

Independent sample t-test revealed no significant difference in personal space sizes between male and female students during active trials with same-gender confederates. However, significant differences were observed in personal space sizes from the south (*P-value* = 0.008) and southwest (*P-value* = 0.025) orientations. In passive trials with same-gender confederates, significant differences in personal space sizes were found in the south (*P-value* < 0.001) and southeast (*P-value* = 0.026) orientations. When assessing differences in personal space sizes during passive trials with different-gender confederates, male and female students demonstrated significant variations in all orientations (*P-value* < 0.05) except the north. Results from one-way ANOVA and Bonferroni post hoc tests showed no significant relationship between personal space sizes and the seniority of the students across any trial (*P-value* > 0.05). The Pearson correlation coefficient was used to determining the correlation between personal space sizes and quantitative demographic variables. There were weak positive significant relationships among students' height and personal space

sizes in active same-gender confederate trials in southeast orientation, active different-gender confederate trails in south and southeast orientations, and also passive same-gender confederate trials in the south and southeast orientations (*P-value* < 0.05, 0.1< r > 0.3). However, there was a weak negative significant relationship among students' height and weight and the passive different-gender trials in all directions instead of the north (*P-value* < 0.05, -0.3 < r > -0.1). There was no significant relationship between BMI and age with personal space sizes.

To propose an arrangement based on the personal space sizes, we used the 95th percentiles of each trial for male and female students. Figure 1 shows the radar chart for the 95th percentile for different trials.

Table 2. Students' personal space dimensions in active trials

Direction	Parameter	Male SGC*	Female SGC*	Male DGC*	Female DGC**
North	Mean ± SD	43.71 ± 18.65	44.25 ± 20.35	58.44 ± 20.35	60.60 ± 20.16
	5th Percentile	16	12	28	30.80
	95th Percentile	77.5	80.40	98.50	93.60
North-East	Mean ± SD	44.40 ± 19.25	46.02 ± 19.15	57.30 ± 20.86	59.17 ± 20.06
	5th Percentile	12.50	15	25	30.60
	95th Percentile	80.50	79.20	99.50	96.20
East	Mean ± SD	47.67 ± 18.32	48.45 ± 18.53	61.50 ± 21.51	61.67 ± 20.07
	5th Percentile	17	20.4	27	35.80
	95th Percentile	80.50	78.4	100	99
South-East	Mean ± SD	48.02 ± 21.10	45.07 ± 20.76	62.71 ± 21.52	57.07 ± 21.67
	5th Percentile	15.50	12.80	27	26.80
	95th Percentile	88.50	83	101	96.60
South	Mean ± SD	50.89 ± 21.78	46.52 ± 24.12	67.41 ± 20.53	58.97 ± 24.43
	5th Percentile	18	11.80	35	25
	95th Percentile	93.50	97.20	102	104.40
South-west	Mean ± SD	49.62 ± 21.21	45.03 ± 21.69	63.83 ± 20.39	57.27 ± 21.89
	5th Percentile	16.50	16.80	32	27.80
	95th Percentile	90.50	84.40	101	98
West	Mean ± SD	47.17 ± 18.28	45.25 ± 19.52	61.25 ± 20.01	58.92 ± 20.99
	5th Percentile	18.50	18.60	28.50	29.80
	95th Percentile	79.50	78.60	101	100.20
North-West	Mean ± SD	43.29 ± 19.65	43.62 ± 20.64	59.14 ± 20.83	58.20 ± 22.53
	5th Percentile	11	13.60	29.50	28.80
	95th Percentile	80	78.60	98	104.400

*Same Gender Confederate **Different Gender Confederate

Table 3. Students' personal space dimensions in passive trials

Direction	Parameter	Male SGC*	Female SGC*	Male DGC**	Female DGC**
North	Mean ± SD	49.46 ± 20.71	51.20 ± 23.09	65.78 ± 24.48	71.59 ± 21.22
	5th Percentile	15	12	20	37.800
	95th Percentile	85	89.60	104.50	109
North-East	Mean ± SD	45.31 ± 18.04	45.97 ± 19.33	57.57 ± 21.39	66.05 ± 20.36
	5th Percentile	11.50	12.80	15	34.80
	95th Percentile	79.50	81	92	100.80
East	Mean ± SD	47.16 ± 17.62	46.34 ± 18.37	55.37 ± 21.45	65.53 ± 18.65
	5th Percentile	12	15.80	19	37
	95th Percentile	78	79.4	96.50	99
South-East	Mean ± SD	49.44 ± 20.22	45.65 ± 19.49	55.26 ± 22.61	69.39 ± 19.85
	5th Percentile	14	14.60	16	34.40
	95th Percentile	84.50	83.20	93	97.40
South	Mean ± SD	53.51 ± 28.24	40.49 ± 20.15	48.51 ± 21.62	65.87 ± 19.92
	5th Percentile	11.50	13.80	19.50	32
	95th Percentile	103	79.40	87	100
South-west	Mean ± SD	51.33 ± 22.29	44.73 ± 20.42	54.66 ± 22.81	65.78 ± 19.73
	5th Percentile	15	12.60	17	31.60
	95th Percentile	87.50	79.60	88.50	97
West	Mean ± SD	48.29 ± 20.68	45.27 ± 18.66	56.05 ± 22.21	64.84 ± 17.79
	5th Percentile	15.50	17.40	21.50	35.80
	95th Percentile	82	80.20	94.50	95
North-West	Mean ± SD	44.47 ± 19.82	44.21 ± 20.10	55.19 ± 23.42	65.56 ± 20.51
	5th Percentile	5	16	13	33
	95th Percentile	76	82.20	103.50	99.40

*Same Gender Confederate **Different Gender Confederate

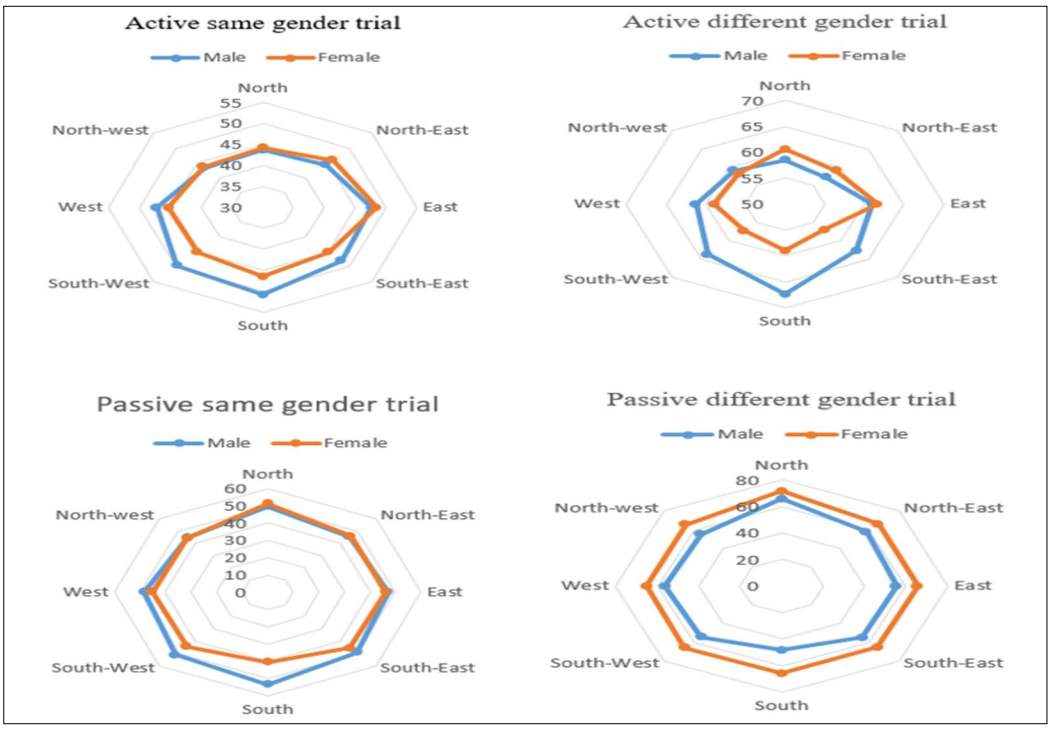

Figure 1. 95th percentiles of personal space sizes and shapes in different trials

The final personal space size was determined by combining the highest values of 95th percentiles for each orientation. The students' highest 95th percentile in personal space was when facing the confederates from the front. Figure 2 shows the radar chart for the proposed personal space size that is acceptable by 95% of the students.

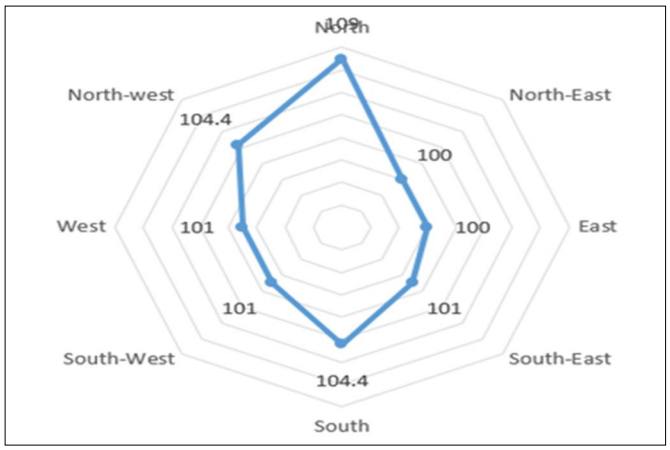

Figure 2. The highest 95th percentiles of personal space sizes and shapes in different trials

The results indicate that only single-seat tables with a 20-centimeter distance meet the criteria for accommodating 95% of the students, making them suitable for providing privacy and comfort. For larger four-seat tables, a new layout was proposed to give students more lateral movement space. Figure 3 illustrates the preliminary and proposed layouts for these seating arrangements.

Based on the 95th percentile of personal space dimensions, a new layout for the entire library was designed. Figure 4 A displays the preliminary library design, where tables are placed too close to each other, potentially intruding on students' personal space. The chairs at the four-seat tables were also positioned too closely. The proposed design introduces a 20-centimeter distance between single-seat tables (to meet the necessary distance based on 95th percentile of west and east personal space sizes that were 100 and 101 cm) and reconfigures the layout of four-seat tables to provide more space. Additionally, the library space is optimized to increase the distance between tables. The proposed layout is shown in Figure 4 B.

This study aimed to assess students' personal space sizes and propose a seating layout pattern for the faculty library. The results revealed significant differences and correlations between personal space dimensions and demographics such as gender, height, and weight. The 95th percentiles of personal space in different orientations were used to develop the proposed seating layout.

Research on personal space size is limited. We found no studies that applied personal space dimensions to educational environment design. In this study, we measured personal space dimensions and, for the first time, proposed a new library seating layout based on the 95th percentile of personal space sizes. Strong and controlled study design controlling and trying to consider all of affective factors were among the strengths of this study.

The shape of personal space varied across trials. Male students tended to have more rounded personal space than females, who exhibited rounder personal space only in passive trials. Male students generally demonstrated larger

personal space sizes than females, except in passive trials with different-gender confederates. Notably, the 95th percentile of personal space in the north (front) orientation was larger than in other orientations. This aligns with prior research, which found that individuals maintained greater distances from confederates approaching from the front (Akande, 1997; Welsch et al., 2019). Students may not expect someone to approach them from the front and might express discomfort by adjusting their sitting orientation, as noted in a previous study (Beaulieu, 2004).

In several active and all passive trials, students reported larger stop distances in the south and southwest orientations. This finding corresponds with the results of Hecht et al. (2019), which suggests that individuals react more cautiously when they cannot fully see the approaching person. Women were observed to maintain larger distances from men in back-oriented approaches. In active trials, male students, in particular, appeared to consider the confederates' comfort, refraining from approaching too closely.

The mean personal space size of the students in this study was smaller than that reported in other studies, which typically ranged from 80 to 100 cm (Holt et al., 2022; Welsch et al., 2019). Our results align more closely with the 95th percentiles of measured personal space sizes. This discrepancy may be attributed to cultural and demographic differences among participants, as previously demonstrated (Beaulieu, 2004). The temperamental culture of eastern societies may cause smaller personal space boundaries. Collectivism and the priority of friendship over personal space that is seen in Iranian culture may minify the dimensions of personal space. Additionally, our findings are comparable to Nishihara's study on personal space in a virtual environment (Nishihara & Okubo, 2015).

Students of both genders reported smaller personal space sizes with same-gender confederates. This contrasts with prior studies (Akande, 1997; Hecht et al., 2019; Nishihara & Okubo, 2015), likely reflecting cultural differences. Male students' personal space sizes in same-gender confederate active trials were smaller than in passive trials, while female students did not exhibit this pattern. This difference may also be linked to cultural characteristics of Iranian society, where males tend to exhibit greater ease in social interactions than females. In active trials, individuals often perceive greater control over the stop distance, resulting in smaller personal space sizes compared to passive trials. However, in several orientations, female students appeared to prefer maintaining greater distances, even with same-gender confederates.

Using personal space data is essential for designing educational environments that cater to students' needs. When students feel comfortable, their performance improves, making it crucial to align design choices with their preferences. In this study, one-seat tables were spaced 20 cm apart to ensure adequate personal space for students. This arrangement is particularly important as there has been a noticeable increase in requests for individual study spaces among students (Min & Lee, 2020). However, many facilities fail to meet students' specific personal space requirements, even though variations in seat layouts significantly impact behaviors such as communication, silence, and interaction (Esmaeili et al., 2019). The preliminary four-seat table design appears more suitable for group studies and collaborative interactions. Nonetheless, Esmaeili et al. (2019) found that round seating arrangements provide students with both increased personal space and enhanced opportunities for interaction compared to other designs. Thus, the proposed layout for four-seat tables aligns well with these findings and can be considered a practical solution, as it is more ergonomic and provides the students more space.

Like any research, this study faced certain limitations. We were unable to compare personal space sizes between single and married students or among students pursuing different degrees. As this was a cross-sectional study, it did not explore cause-and-effect relationships between variables. Additionally, the findings are specific to the study site and may not be generalizable. Future research should involve a larger and more diverse student population, including more master's and Ph.D. candidates, to provide broader insights. The reason for the weak negative relationship among students' height and weight and the passive different-gender trials in all directions instead of the north needs further research.

Figure 3. Seat layouts. A) Single seat table; B) Proposed layout for four-seat tables; C) Preliminary four-seat tables layout

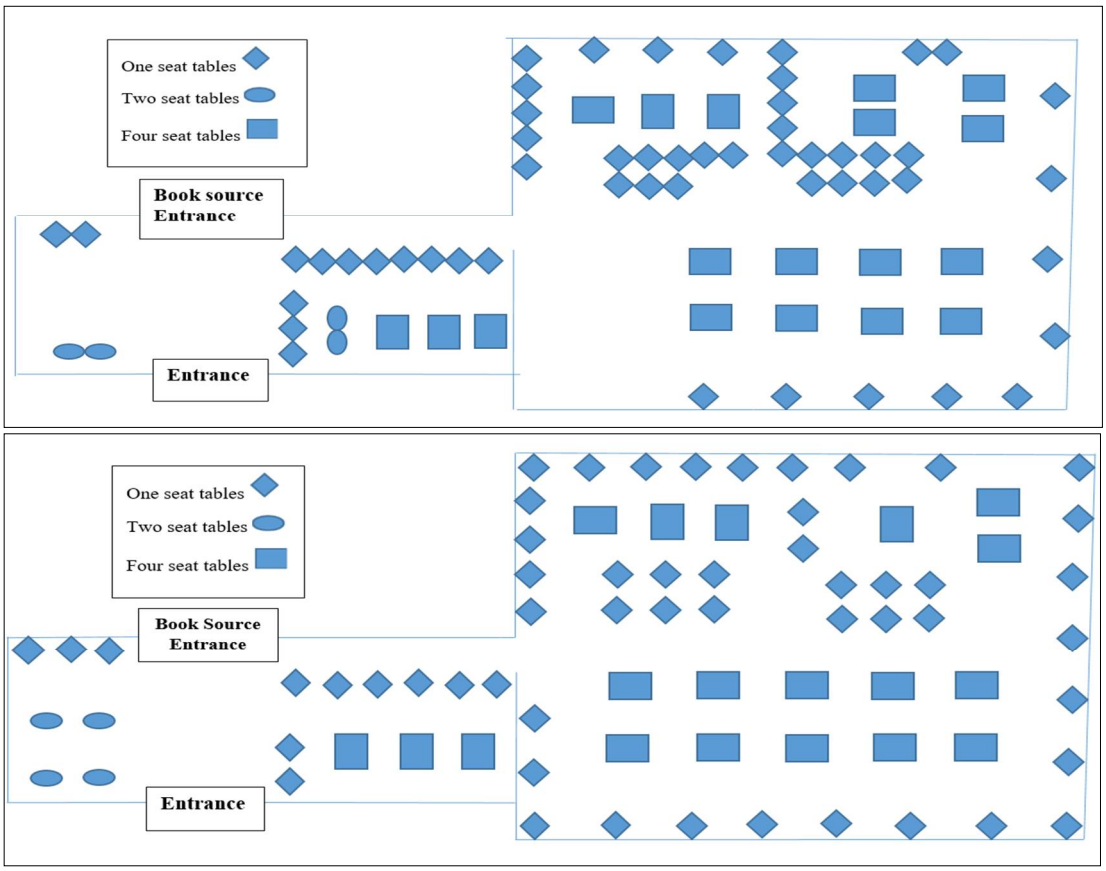

Figure 4. A. The preliminary layout of library, B. The proposed layout of the library based on 95th percentiles of personal space dimensions

4. Conclusion

The study of personal space among university students is crucial, as violations of this space can adversely impact their educational performance. Male and female students exhibit distinct personal space sizes and shapes, with these differences being particularly pronounced when approached from behind. Designing a library layout that respects students' personal space sizes and preferences can create more comfortable environment for study, ultimately enhancing their academic performance and overall satisfaction. This approach may be applicable to other educational environments such as classrooms and group study rooms.

Authors' Contributions

Seyed Reza Azimi Pirsaraei: Conceptualization; Resources; Investigation; Writing; Review and editing. **Reza Kalantari:** Funding acquisition; Study design; Project administration; Methodology; Writing; Review and editing. **Niloofar Shabani Arbusara:** Data curation; Investigation; Visualization; Writing original draft. **Amir Reza Abidi:** Formal analysis; Investigation; Software; Writing; Review and editing. **Parsa Fooladi:** Investigation; Validation; Writing; Review and editing.

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Conflicts of Interest

There are no competing interests in this research.

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Ethical Considerations

The present study has been approved by the Research Ethics Committee of Zanjan University of Medical Sciences (IR.ZUMS.REC.1403.136).

Using Artificial Intelligence

The Artificial Intelligence tools were not used in this research.

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