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Spatial Elements of Middle School Gymnasiums Based on Youth Visual Perception

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ABSTRACT

Middle school students are physically and psychologically different from adults. They are in a relatively special and rapidly changing phase. As the most penetrating level of environmental perception, visual perception directly affects the use of the space in middle school gymnasiums. Based on the human factors engineering problem of teenagers using campus gymnasiums to carry out sports activities, this study takes visual perception as the starting point and adopts the method of combining research and experiment. Through semi-structured interviews and grading questionnaires, the strong factors related to middle school students' willingness to exercise and architectural space design were refined. A seven-differentiation evaluation scale was constructed by SD method, and a questionnaire survey was conducted on 1150 middle school students. Multiple linear regression analysis was performed on the statistical data, and multiple groups were compared by age group and gender, and thus corresponding design strategies were proposed. The paper aims at promoting the enthusiasm of youth sports development, and providing theoretical support for the construction and development of middle school gymnasiums.

Keywords: Visual perception, Teenagers, Middle school gymnasium, Multiple linear regression

INTRODUCTION

Generally speaking, when children encounter differentiation problems, they will receive more extensive help and attention from adults, but in the transition period of "adolescence", teenagers often no longer receive such attention (S.P. Chaube et al. 1985). Middle school students are generally between 13 and 18 years old. They are in a period of dramatic physical and psychological changes. Their physical development and psychological needs are different from adults and children. They are in the puberty period of individual development. During this period, the sensitivity of adolescents to external factors, especially those related to school education, increases sharply (Dubrovinskaya et al. 2000). The campus gymnasium is the most common activity carrier for teenagers. Whether the architectural environment design has an impact on the willingness of young people to exercise, and the degree of influence of different factors on different age groups are the main points

of this study.In the use of the method of semantic differential, the subjects were asked to evaluate different visual elements in the campus gymnasium on a nine-item seven-point semantic scale, so as to understand the meaning and intensity of each element in the different dimensions being evaluated. SPSS data analysis software was used to conduct multiple linear regression analysis on the strong correlation factors between middle school students' willingness to exercise and architectural space design, and the significant correlation factors affecting middle school students' willingness to exercise and the degree of influence of different factors were summarized. Through the analysis and comparison of middle school students aged from 13 to 18 in different grades and genders, it is found that teenagers have different perception of the sports environment in the gymnasiums in different stages of growth and development, and there is a significant difference compared with adults.

LITERATURE REVIEW ON TEENAGERS' VISUAL PERCEPTION OF CAMPUS GYMS

The Influence of Visual Perception on Exercise Intention

In 1951, Graham CH reviewed the visual perception literature (Graham CH et al. 1951). In 1973, *The psychology of visual perception* (Haber RN et al. 1973) introduced the three main areas of visual perception: sensory organization, information processing, and spatial organization. Key topics included theoretical and empirical evidence on the mechanisms by which color, form, and motion were perceived. In 1995, Jane L. Harte, Georg H. Eifert tested the psychoneuroendocrine effects of exercise-induced emotional experiences and the mediating effects of environmental setting and subjects' attentional focus (Jane L. Harte et al. 1995). In 2002, Kahn Jr et al. proposed the differences between children and adults in cognitive science, and there is also evidence that people of different ages have different sensitivity to the environment (Kahn Jr et al. 2002). In 2009, D Araujo et al. proposed the influence of sports environment on sports cognition and sports attitude in *International Journal of Sport Psychology* (D Araujo et al. 2009). In 2015, White MP et al. conducted a study on the influence of the environment on the willingness to exercise in postmenopausal women, and a small-scale experiment pointed out that different environments had different effects on the willingness to exercise (White M P et al. 2015).

The above research has largely summarized the effects of visual perception on people's willingness to exercise, from the initial research on the objective causes and changes of vision based on the entry point of human physiology degree to the impact of visual perception on people in different objective states.

The earliest research on the effect of age on visual perception came from the medical field, explaining the link between age and the level of brain response in terms of physiological feedback. In the summary of the development process of the research, the visual perception of different age groups and genders is gradually refined, and visual perception is also subdivided into distance perception, time perception, etc. The subjects of this study are young

adults between the ages of 13 and 18, who still have a big gap with adults in psychology and physiology.

METHODOLOGY

Research and Interviews

The objectives are as follows: 1. Select typical objectives of scientific research across the country; 2. Discover the similarities and differences between middle school gymnasiums and other gymnasiums; 3. Determine the main influencing factors of visual perception of middle school students' gymnasiums.

1. Research object

In the preliminary investigation, the focus of in-depth research was mainly to classify the visual elements as follows: volume, form, interface, equipment (lighting), and the volume includes the length-width ratio and height of the space; the interface includes the virtual and real interface (permeability), lighting conditions, interface materials and interface colors; the equipment is mainly based on the selection of lighting equipment. Finally, 9 expected influencing factors were extracted: space height, aspect ratio, space form, space brightness, light source mode, lighting equipment, space color, space material, space permeability.

2. Questionnaire Design Based on SD Method

The questionnaire consists of four parts: basic information of respondents, usage of campus gymnasium, willingness to exercise and influencing factors, and SD evaluation of spatial visual perception. Considering the age of the subjects, all the special terms in the questionnaire were explained. At the same time, all the questionnaires were distributed and collected on site and questions of the respondents about the questionnaire were answered on site.

A) Basic information of respondents.

It includes respondents' gender, age, grade, height, and weight.

B) Campus gym usage.

It includes collecting weekly frequency of exercise and time ranking of exercise types.

C) Exercise willingness and categories of influencing factors.

The exercise willingness was scored on a 5-division scale, and the ranking of the factor categories that affected the exercise willingness was collected.

D) SD evaluation of visual perception of motion space.

The semantic scale is set according to the "bi-Polar" principle, with 0 as the midpoint, and is divided into 7 levels. For the nine neutral factors of adolescent spatial visual perception, nine groups of adjectives corresponding to advance were collected (as shown in Figure 1). According to the requirements for setting the difference table, the level of this survey was divided into 7 levels, from left to right: extremely poor, very poor, generally poor, neutral, generally good, very good and extremely good, corresponding to seven scores of −3, −2, −1, 0, 1, 2 and 3.

Table 1. Basic information of research cases.

Case number	A	B	C	D	E	F	G
							
Width× depth× height(m)	28×20×6	28×20×9	15×30×7	60×30×20	45×50×8	30×20×7	15×30×9
Conditions of window	185	344	144	102	156	304	166
Conditions of window	Single side high side window and partial top window	Single side transverse window	Single side vertical window	Bilateral high window	vertical high and top window	Bilateral vertical windows	Local transverse window
Interior	White paint + wood pavement	White	White paint + wood pavement	Brown and orange	Yellow	White	Green

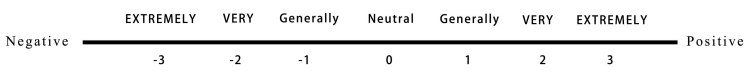

Figure 1: Seven differentiation scale.

3. Participants

Two junior high schools and five senior high schools in China were selected, including four grades in junior high schools and three grades in senior high schools. 50 students from each grade were randomly selected from a class, a total of 1050 students (M = 610, F = 440, Age = 12~18, Mean Age = 15.8). Through preliminary screening of the data, the effective sample size was 879 (sample effective rate was 83.7%). Another 200 adults were selected for comparison (M = 114, F = 86, Mean age = 24.7).

4. Statistical Analysis

SPSS software was used for statistical analysis to carry out descriptive statistics and multiple linear regression analysis on the data. Due to the large number of predicting influencing factors, step-back regression was used, and the variables were screened one by one and put into the regression equation to effectively eliminate the statistical impact of the non-conforming factors in the prediction variables on other factors.

RESULTS AND DISCUSSION

Multiple Linear Regression

The nine target variables (height, aspect ratio, shape regularity, brightness, light source mode ratio (natural light/artificial light), cold and warm light source ratio, color softness, interface permeability, decorative material ratio (natural material)/artificial materials)) and the dependent variable (willingness to exercise) were analyzed by multiple linear regression to establish a causal relationship between multiple variables. In statistics, it is required that all independent variables be independent of each other and there is no multicollinearity. The collinearity test and Debin Watson (DW) test (VIF < 5, 1.5 < DW < 2.5) were carried out for all the following regression models, and the regression method was used for stepwise regression. Through the observation of significance in the model (P < 0.05 was significantly correlated), the visual perception factors under different conditions were judged, and the degree of correlation among the significant correlation factors was discussed combined with the unstandardized coefficient (β).

In Figure 2, the results show that the spatial height, brightness, color and material characteristics of campus gymnasium have significant influence on teenagers' willingness to exercise.

The above four independent variables were observed as non-standardized coefficients (β), and it was found that there was a small difference in the influence degree of the four independent variables on the willingness to exercise, which were brightness ($\beta = 0.060$) < color softness ($\beta = 0.073$) < space height ($\beta = 0.076$) < the ratio of decorative materials (natural materials/artificial

Male Coefficient a

Model		Non standardized coefficient		Standardization coefficient	t	Significance	Collinearity Statistics	
		B	Standard error	Beta			Tolerance	VIF
3	(Constant)	3.013	.158		19.011	.000		
	Height	.254	.111	.377	2.285	.027	.242	4.125
	L/W	.439	.128	.607	3.433	.001	.211	4.737
	Brightness	.560	.082	.723	6.841	.000	.591	1.692
	Light source mode ratio	-.358	.082	-.538	-4.391	.000	.440	2.272
	Ratio of cold and warm light sources	.228	.088	.319	2.593	.013	.435	2.298
	P of DM	-.133	.048	-.281	-2.772	.008	.642	1.558
	Permeability	.201	.085	.293	2.377	.022	.435	2.298
Adjusted R-square					0.664			
DW Value					1.906			

Junior High School Girl Group Coefficient a

Model		Non standardized coefficient		Standardization coefficient	t	Significance	Collinearity Statistics	
		B	Standard error	Beta			Tolerance	VIF
8	(Constant)	2.832	.214		13.217	.000		
	Height	.461	.115	.481	4.014	.000	.968	1.033
	Light source mode ratio	-.251	.067	-.453	-3.780	.001	.968	1.033
Adjusted R-square					0.514			
DW Value					1.543			

Junior High School Girl Group Coefficient a

Model		Non standardized coefficient		Standardization coefficient	t	Significance	Collinearity Statistics	
		B	Standard error	Beta			Tolerance	VIF
8	(Constant)	2.832	.214		13.217	.000		
	Height	.461	.115	.481	4.014	.000	.968	1.033
	P of DM	.251	.067	.453	3.780	.001	.968	1.033
Adjusted R-square					0.514			
DW Value					1.543			

High School boy Group Coefficient a

Figure 2: Three groups of correlation comparison distinguished by gender.

materials) ($\beta = -0.095$). Brightness, color softness and height were positively correlated with motion intention, while the ratio of decorative materials (natural materials/artificial materials) was negatively correlated with motion intention.

	Model	Non standardized coefficient		Standardization coefficient	t	Salience	Collinearity Statistics	
		B	Standard error	Beta			Tolerance	VIF
7	(Constant)	3.689	.084		44.003	.000		
	Brightness	-.109	.049	-.138	-2.212	.028	.842	1.187
	Color softness	.166	.056	.182	2.962	.003	.867	1.153
	Permeability	-.079	.044	-.114	-1.810	.071	.829	1.207
Adjusted R-square					0.061			
DW Value					1.898			

High School Girl Group Coefficient a

	Model	Non standardized coefficient		Standardization coefficient	t	Salience	Collinearity Statistics	
		B	Standard error	Beta			Tolerance	VIF
8	(Constant)	3.255	.081		40.054	.000		
	Brightness	.121	.047	.161	2.591	.010	.957	1.045
	P of DM	-.066	.036	-.115	-1.854	.065	.957	1.045
Adjusted R-square					0.043			
DW Value					2.039			

Adult Male Group Coefficient a

	Model	Non standardized coefficient		Standardization coefficient	t	Salience	Collinearity Statistics	
		B	Standard error	Beta			Tolerance	VIF
8	(Constant)	3.285	.200		16.421	.000		
	Brightness	.291	.116	.283	2.515	.014	.922	1.085
	Permeability	.236	.087	.305	2.709	.008	.922	1.085
Adjusted R-square					0.101			
DW Value					2.269			

a. Dependent variable: willingness to exercise

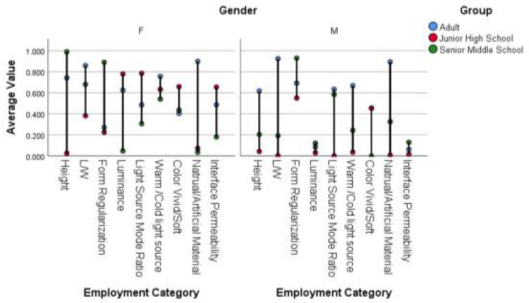

Figure 2: Continued.

Multiple Linear Regression for Different Ages

According to the relationship between visual perception and age in the previous article, the second stage mainly studies the relationship between spatial

Table 2.

Group/Significant Correlation	Teen group	Junior high school group			High school group			Adult group		
		H	M	F	Hole	M	F	Hole	M	F
Height	✓		✓	✓		✓				
L/W		✓	✓							
Morphological										
Brightness	✓		✓		✓	✓	✓	✓	✓	
Light source mode			✓							
Ratio of cold and warm light sources			✓							
Color softness	✓	✓								
Proportion of DM	✓	✓	✓	✓						
Interface Permeability		✓	✓				✓		✓	

visual perception and motor willingness of different age groups. The subjects were divided into two groups: junior high school group and senior high school group. The junior high school group includes school A and school C, each with 400 students in 4 grades, and the senior high school group includes school BDEFGH, with 650 students in 3 grades. Multiple linear regression was performed on the two groups separately, and the adult group was added for comparison.

From the comparison between the two groups, each age group has different feedbacks on the factors strongly related to visual perception that affect the willingness to exercise, but the relationship between the willingness to exercise and the visual perception factors in the junior high school group is significantly stronger than that in the senior high school group. Through the significance line chart of nine independent variables, it can be found that the junior high school group is better than the senior high school group in the number of significant related factors and the average value of P value. When comparing the data of the adult group, it is found that the visual influence factors (permeability) of the adult group are different from those of teenagers, and the significance of the adult group is close to and slightly worse than that of the senior high school group. It can be seen that the p value of junior high school group is less than that of senior high school group and less than that of adult group, and the degree of change shows a decreasing trend.

Multiple Linear Regression by Gender

The third phase investigates the effect of gender on the correlation between visual perception and motor intention. All data were divided into six groups, namely: junior high school boys/girls group, senior high school boys/girls group, and the comparison group adult male/female group.

Comparing the significance of the above six groups of data and drawing a line graph, it is found that in the age group of 12 to 30 years old, women's willingness to exercise is less affected by visual perception than men, and

the impact of visual perception on exercise willingness increases with age. The increase shows a decreasing trend. Among the 6 groups of data, the willingness to exercise of the junior high school boys group is most affected by spatial visual perception, and seven spatial visual perception elements show a significant impact on willingness to exercise, while the adult female group shows no independent variable related to willingness to exercise.

CONCLUSION

From the horizontal observation in Table 2, the visual element of brightness has the highest frequency among all groups. Ensuring natural lighting in stadium design and timely enabling of lighting equipment in use will have a positive impact on teenagers' willingness to exercise. The two factors of height and the ratio of decorative materials mainly appear in the adolescent group, and there is no obvious correlation in the adult group. This indicates that the space height and material selection in the gym will be related to the willingness to exercise in the adolescent stage. The integration of natural language, the selection of materials and colors, and the increase of the height of the main space are conducive to the voluntary participation of teenagers in sports design methods; Interface permeability has a significant correlation with exercise intention in both adolescent group and adult group, and both have a positive correlation with dependent variables.

Campus gymnasiums are different from social gymnasiums. Social gymnasiums often need to undertake social functions such as city symbols in addition to their use functions, while the design of campus gymnasiums needs to be centered on the healthy development of students. Through subdivided research on teenagers' exercise intention, a design method for middle school campus gymnasiums is proposed to promote the enthusiasm of youth to exercise actively, which will play an important role in the healthy development of youth physique.

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