Research on Motor Function of the Elderly in Guangzhou Based on Anthropometry

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Abstract. Taking the elderly in Guangzhou as an example, this paper collects the data of elderly upper limb range of motion by manual measurement. After analyzing the data of elderly upper limb range of motion, the anthropometry database of older people in Guangzhou was established, and the upper and lower limits of the range of motion of elderly products can be get from this database. Also, the anthropometry database can provide the valid date as a design basis for the outdoor fitness products which are tailored to the elderly in Guangzhou.

Keywords: Guangzhou · Elderly · Anthropometry measurement
Range of motion

1 Introduction

With the development and improvement of social living standards and the aggravation of the aging of society, the awareness of fitness of the elderly in urban areas are increasing constantly. According to a survey, more than 60% of the elderly in urban areas are exercising, and more and more elderly people have a strong sense of fitness and are actively involved in the exercise [1].

Many communities in the city are equipped with a variety of fitness equipment for elderly, however, these fitness equipment are designed according to the Chinese adult human body size (for example, national standard GB/T10000-88, its human body data was collected from male not over the age of 60 and female not over the age of 55) as the design standard, thus does not conform to the human activity scale and meet the fitness requirement of the elderly. With the improvement of the health consciousness of the elderly, more and more elderly people are actively participating in the fitness activities, which puts forward more stringent requirements on the design of fitness products.

Guangzhou fully entered the aging society in 2005, and more and more elderly joined in the fitness team. Although anthropometric measurement is difficult, time-sensitive, and there are obvious differences among different regions, however, with the increasing of the aging population and the products designed for elderly,

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conducting the elderly anthropometry in a region is at the opportune moment. Therefore, this paper randomly selected the elderly in the community and collected their human body data and analyzed the data in order to provide a data reference for the design of the elderly fitness product in Guangzhou.

2 Guangzhou Elderly Anthropometric Sample Selection

This paper selects the elderly between 60 to 70 years old in Guangzhou as the research object, because according to the survey, more than half of the elderly in Guangzhou are between 60−70 years old. Elderly at this age also has stronger activity ability and more likely to choose to exercise with the fitness equipment [2].

This paper adopts the simple random sampling method and set up the small data sample by means of sampling measurement. A reasonable sample size can ensure the validity of the data. According to the sample estimation method recommended by the international standard ISO15535 [3], the following formula is obtained:

$$n = \left(\frac{Z \times CV}{\alpha}\right)^2 \times 1.534^2 \tag{1}$$

In the formula: Z is a normal value. To ensure the accuracy of the measured data, select the 95th percentile value Z = 1.96; α is relative error percentage; CV is the coefficient of variation (CV = SD/M $\times$ 100, SD is the standard deviation, M is the mean value). Because of the lack of relevant data reference to determine the CV value, considering the manpower and time factor, we preliminarily determine the sample as 50 elderly men and women. The CV value can be calculated according to the actual measured sample size. Using formula (1) to calculate the relative error percentage α, if the value of α is acceptable, then the effective sample size is reasonable, otherwise the sample size is small. The measured data should be used carefully.

3 Measure Content and Method

3.1 Measure Content

This paper mainly aimed at Guangzhou elderly upper limbs motion range measurement. According to the literature, the current outdoor fitness equipment, such as running trainers, elliptical machine, riding machine are focusing on the exercise of lower limbs. They require a large range of movement and a good sense of balance and mobility. Therefore, only the elderly with better physical quality will use the equipment. The exercise equipment that focuses on the upper part of the limbs such as arm extension apparatus, the suspension loop, the tractor back massager, big wheel, tai chi wheel and push plate, however, are more popular among the elderly as they do not consume much physical strength and do not need a large range of movement but can also achieve exercise effect [4]. In consequence, this paper selects the elderly upper limbs motion range as the research object.

Dynamic joint range of motion refers to the angle parameters of the limbs and the rotation angle of the center of gravity location (near the center of the body joints) of human body parts in active position. This paper studies and measures the human upper limbs joint range of motion, including the head, neck, shoulder, elbow and the waist. The measure contents are listed in Table 1.

Table 1. Measure contents of range of motion.

Body parts	Joint	Activity
Head to the trunk	Head joint	Bowed head, raise head Tilt to left, tilt to right Turn left, turn right
Trunk	Chest joints, waist joints	Bend forward, bend backward Bend to left, bend to right Turn left, turn right
Upper arm to trunk	Shoulder joint	Sway outward, sway inward Sway upward, sway downward Sway forward, sway backward
Lower arm to upper arm.	Elbow joint	Sway outward, sway inward Sway upward, sway downward sway forward, sway backward
Hand to lower arm	Wrist joint	Sway outward, sway inward Bend, stretch
Hand to the trunk	Shoulder joint, lower arm	Turn left, turn right

3.2 Methods of Motion Range Measurement

Anthropometric can be conducted by manual measurement, two-dimensional non-contact body measurement and 3d human body measurement technology [5]. During the measurement, the body posture change will make human body parts contour change, which will cause larger deviation if use two-dimensional or three-dimensional measurement method. Meanwhile, some places cannot be scanned by the machine, which will cause inconvenience for the data collection. After analyzing the existing conditions and comparing the above methods, this paper chooses the manual measurement method, and the contact measurement is carried out by using the joint range of motion meter. In the measurement, the fixed arm of the meter is fixed at the fixed point of the volunteer horizontally or vertically; Then let the volunteer sway their arm to their best efforts, record the value on the angle dial, that is, to get the range of motion [6].

Before conducting the contact measurements, we told the details of the measurement to the elderly, and began to measure after reaching consensus with the elderly. Due to the obvious differences between the mobility and the maximum motion range of the elderly, we took the maximum range of motion that they willing to exert as the final measurement results.

4 Collection and Analysis of Measurement Data

4.1 Statistics of the Range of Motion of Elderly Upper Limb

This paper processes the measured data according to the gender and analyzes the data by using the statistical software SPSS23.0. The average motion range values (M), the minimum (min), the maximum (Max), the standard deviation (SD) and coefficient of variation (CV) of the elderly can be obtained [7]. While the motion range of different individuals is distributed in a certain range, we can only use a certain value but not the average value in the design. So this subject adopts the percentile (divided the total number of people by the number of people that equal to or less than the range of motion) to describe the data. The results are listed in Tables 2, 3, 4 and 5.

Table 2. Table of Guangzhou male elderly range of motion measurement (°).

Measure content	N	Min	Max	M	SD	CV (%)
Bow head+	48	25	59	40	9	22.5
Raise head–	48	16	52	32	10	31.3
Tilt head leftward+	48	25	52	38	6	15.8
Tilt head rightward–	48	25	52	38	6	15.8
Turn head leftward+	48	32	62	44	9	20.5
Turn head rightward–	48	32	62	44	9	20.5
Bend trunk forward+	48	68	105	93	10	10.8
Bend trunk backward–	48	20	54	38	12	31.6
Bend trunk leftward+	48	27	50	38	7	18.4
Bend trunk rightward–	48	27	50	38	7	18.4
Turn trunk leftward+	48	28	55	41	8	19.5
Turn trunk rightward–	48	28	55	41	8	19.5
Bend hip joint forward+	48	80	130	106	12	11.3
Bend hip joint backward–	48	10	30	18	6	33.3
Bend hip joint outward+	48	20	44	31	7	22.6
Bend hip joint inward–	48	9	21	14	3	21.4
Turn hip joint outward+	48	95	119	104	6	5.8
Turn hip joint inward–	48	57	75	64	5	7.8
Sway shoulder joint outward+	48	170	180	178	3	1.7
Sway shoulder joint inward–	48	20	43	27	6	22.2
Sway shoulder joint upward+	48	175	180	179	2	1.1
Sway shoulder joint downward–	48	15	51	39	9	23.1
Sway shoulder joint forward+	48	125	162	137	8	5.8
Sway shoulder joint backward–	48	25	60	38	9	23.7
Bend elbow joint+	48	102	153	134	146	109.0
Stretch elbow joint	48	0	0	0	0	–
Sway wrist outward+	48	20	61	35	10	28.6
Sway wrist inward–	48	15	32	24	5	20.8
Bend wrist+	48	50	82	71	6	8.5
Stretch wrist–	48	30	68	58	7	12.1

Table 3. Percentile of Guangzhou male elderly range of motion measurement (°).

Measure content	1	5	10	50	90	95	99
Bow head+	25	26	29	40	53	57	59
Raise head–	16	18	19	29	50	52	52
Tilt head leftward+	25	26	30	38	45	47	52
Tilt head rightward–	25	26	30	38	45	47	52
Turn head leftward+	32	33	35	41	57	60	62
Turn head rightward–	32	33	35	41	57	60	62
Bend trunk forward+	68	69	74	95	102	104	105
Bend trunk backward–	20	21	23	39	52	53	54
Bend trunk leftward+	27	28	29	38	48	49	50
Bend trunk rightward–	27	28	29	38	48	49	50
Turn trunk leftward+	28	29	31	43	51	53	55
Turn trunk rightward–	28	29	31	43	51	53	55
Bend hip joint forward+	80	84	86	104	120	128	130
Bend hip joint backward–	10	11	13	18	28	29	30
Bend hip joint outward+	20	21	23	30	40	43	44
Bend hip joint inward–	9	10	11	13	19	20	21
Turn hip joint outward+	95	96	97	104	113	118	119
Turn hip joint inward–	57	58	59	62	72	74	75
Sway shoulder joint outward+	170	170	175	180	180	180	180
Sway shoulder joint inward–	20	21	23	28	35	42	43
Sway shoulder joint upward+	175	175	176	180	180	180	180
Sway shoulder joint downward–	15	22	23	42	48	50	51
Sway shoulder joint forward+	125	126	128	136	150	152	162
Sway shoulder joint backward–	25	26	27	36	54	58	60
Bend elbow joint+	102	103	108	138	151	152	153
Stretch elbow joint	0	0	0	0	0	0	0
Sway wrist outward+	20	25	26	32	50	60	61
Sway wrist inward–	15	16	17	25	29	30	32
Bend wrist+	50	59	60	71	78	80	82
Stretch wrist–	30	49	51	58	65	67	68

4.2 Sample Size Verification

The elbow bend coefficient of variation of male elderly is 109, the sample size is 50, the 95th percentile corresponding Z value is 1.96. The a % is 47.5% calculated by the formula, but this data should be use cautiously. In addition, the other a % of the male elderly men motion range is less than 15%, among the acceptable range. The maximum variation coefficient of female elderly is 29.4, the sample size is 50, the 95th percentile corresponding Z value is 1.96. Calculated by the formula, the a % is 12.5%, less than 15%. The rest of the data are also in the acceptable range.

Table 4. of Guangzhou female elderly range of motion measurement (°).

Measure content	N	Min	Max	M	SD	CV (%)
Bow head+	52	20	60	42	9	21.4
Raise head–	52	15	50	31	8	25.8
Tilt head leftward+	52	20	52	37	8	21.6
Tilt head rightward–	52	20	52	37	8	21.6
Turn head leftward+	52	25	70	44	10	22.7
Turn head rightward–	52	25	70	44	10	22.7
Bend trunk forward+	52	60	120	90	11	12.2
Bend trunk backward–	52	20	55	40	11	27.5
Bend trunk leftward+	52	20	70	40	9	22.5
Bend trunk rightward–	52	20	70	40	9	22.5
Turn trunk leftward+	52	28	65	41	8	19.5
Turn trunk rightward–	52	28	65	41	8	19.5
Bend hip joint forward+	52	83	126	107	10	9.3
Bend hip joint backward–	52	9	30	17	5	29.4
Bend hip joint outward+	52	18	50	34	8	23.5
Bend hip joint inward–	52	9	25	15	3	20.0
Turn hip joint outward+	52	94	125	106	6	5.7
Turn hip joint inward–	52	56	80	65	5	7.7
Sway shoulder joint outward+	52	160	180	179	4	2.2
Sway shoulder joint inward–	52	19	50	30	6	20.0
Sway shoulder joint upward+	52	175	180	179	1	0.6
Sway shoulder joint downward–	52	20	70	43	11	25.6
Sway shoulder joint forward+	52	125	170	142	10	7.0
Sway shoulder joint backward–	52	28	65	42	10	23.8
Bend elbow joint+	52	100	160	137	13	9.5
Stretch elbow joint	52	0	0	0	0	–
Sway wrist outward+	52	23	60	37	9	24.3
Sway wrist inward–	52	16	45	27	7	25.9
Bend wrist+	52	60	80	71	5	7.0
Stretch wrist–	52	50	70	58	5	8.6

4.3 Compare Male and Female Data by ANOVA

The differences between the genders cause differences between the data. And the difference degree determines whether the design size differences between men and women should be considered. In order to determine the degree of data difference between men and women, we have collected the single factor analysis of variance (ANOVA) of the joint range of motion to test the difference degree of the elderly human body data caused by the gender. Its principle is: the difference between the mean of different group are caused by the experimental condition and random error. Through the analysis of different sources of variation of total variation of contribution, we can know the influence of controllable factors on the results [8]. Group the men and

Table 5. Percentile of Guangzhou female elderly range of motion measurement (°).

Measure content	1	5	10	50	90	95	99
Bow head+	20	24	30	42	54	56	60
Raise head–	15	16	19	30	41	46	50
Tilt head leftward+	20	24	26	38	46	51	52
Tilt head rightward–	20	24	26	38	46	51	52
Turn head leftward+	25	31	32	43	56	65	70
Turn head rightward–	25	31	32	43	56	65	70
Bend trunk forward+	60	63	70	92	102	104	120
Bend trunk backward–	20	21	22	43	53	54	55
Bend trunk leftward+	20	24	27	39	50	60	70
Bend trunk rightward–	20	24	27	39	50	60	70
Turn trunk leftward+	28	29	30	42	48	64	65
Turn trunk rightward–	28	29	30	42	48	64	65
Bend hip joint forward+	83	84	92	106	121	124	126
Bend hip joint backward–	9	10	11	17	23	25	30
Bend hip joint outward+	18	19	22	34	48	49	50
Bend hip joint inward–	9	10	12	15	19	20	25
Turn hip joint outward+	94	95	99	105	113	115	125
Turn hip joint inward–	56	57	59	63	72	75	80
Sway shoulder joint outward+	160	170	178	180	180	180	180
Sway shoulder joint inward–	19	20	22	30	36	41	50
Sway shoulder joint upward+	175	176	178	180	180	180	180
Sway shoulder joint downward–	20	23	31	42	57	64	70
Sway shoulder joint forward+	125	127	133	139	153	164	170
Sway shoulder joint backward–	28	29	34	39	60	63	65
Bend elbow joint+	100	102	125	137	151	152	160
Stretch elbow joint	0	0	0	0	0	0	0
Sway wrist outward+	23	25	28	35	50	59	60
Sway wrist inward–	16	18	19	26	35	43	45
Bend wrist+	60	63	64	72	78	79	80
Stretch wrist–	50	51	53	59	65	69	70

women data, establish the test hypothesis H0: The mean of all the samples is the same. The inspection level is 0.05. If the significance value > 0.05 means accepting H0 assumption, shows that there are little data differences between men and women; Otherwise the difference is significant. Results are shown in Fig. 1.

The figure of significant coefficient analysis shows that there are significant differences in the motion range of swaying shoulder joint upward and backward. Beyond that, there are little difference between the male and female data in the upper limb motion range comparison, which shows the consistence in the elderly people upper limbs motion range. Therefore, designers can use the same size to design upper limb movement fitness products to Guangzhou elderly man and woman.

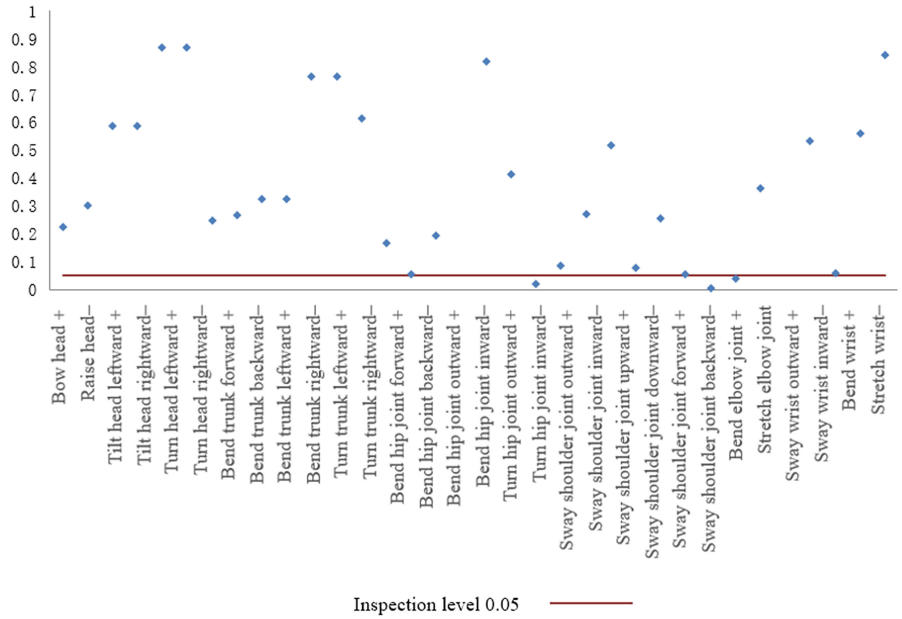

Fig. 1. Figure of significant coefficient distribution of Guangzhou elderly men and women upper limbs motion range.

While the motion range of different individuals is distributed in a certain range, we can only use a certain value but not the average value in the design. According to national standard GB/T12985-1991 general principles of the application of human body size percentile in product design, it needs two human body size percentile as the upper limit value and the lower limit value for the design of fitness products. To ensure consumers' health and safety, and reduce the production cost and simplify the manufacture principle, we should choose male size P95 as the upper limit size, and choose women size P5 as the lower limit [9].

We manage to get the size design basis after constructing the Guangzhou elderly upper limbs motion range database: the 5th percentile of female and 95th percentile of male, the results are shown in Tables 4, 5 and 6, it can be used as a data reference for related fitness products design.

4.4 Analysis of the Elderly Upper Limb Motor Function

Through the observation and statistics of the measurement, we found that the motion range of multiple joint of the elderly decreased. This is due to the decline in the elasticity of soft tissue around the joints as the age increases, and the extensibility and elasticity of the muscles around the joints decrease, leading to the inability of the joints to fully extend or contract. When doing posture such as raising head, swaying shoulder joint backward, bend trunk leftward, rightward and backward, many elderlies feel

Table 6. The 95 percentile value of Guangzhou male and female elderly motion range measurement.

Measure content	Female P5	Male P95
Bow head+	24	57
Raise head–	16	52
Tilt head leftward+	24	47
Tilt head rightward–	24	47
Turn head leftward+	31	60
Turn head rightward–	31	60
Bend trunk forward+	63	104
Bend trunk backward–	21	53
Bend trunk leftward+	24	49
Bend trunk rightward–	24	49
Turn trunk leftward+	29	53
Turn trunk rightward–	29	53
Bend hip joint forward+	84	128
Bend hip joint backward–	10	29
Bend hip joint outward+	19	43
Bend hip joint inward–	10	20
Turn hip joint outward+	95	118
Turn hip joint inward–	57	74
Sway shoulder joint outward+	170	180
Sway shoulder joint inward–	20	42
Sway shoulder joint upward+	176	180
Sway shoulder joint downward–	23	50
Sway shoulder joint forward+	127	152
Sway shoulder joint backward–	29	58
Bend elbow joint+	102	152
Stretch elbow joint	0	0
Sway wrist outward+	25	60
Sway wrist inward–	18	30
Bend wrist+	63	80
Stretch wrist–	51	67

difficult or fail to stretch properly, because these are not our common daily actions and we neglect to practice targeted exercise for a long time [10].

5 Conclusion

Through the actual measurement and the analysis of the Guangzhou elderly upper limbs range of motion data, this paper comes up with the data scope of the fitness products designed for the elderly in Guangzhou according to the national design

standard, provides an effective data basis for the Guangzhou elderly fitness products design. At present the elderly fitness products cannot set a reasonable range of motion for the elderly. To achieve the reasonable fitness effect and make fitness products more suitable for the elderly, more accurate human body data are needed in order to provide the reference for the design.

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