

## 한국 성인용 표준 휠체어의 인간공학적 설계

### Ergonomic Design of Standard Wheelchair for Korean Adults

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#### ABSTRACT

This study discusses a possible ergonomics application for adult wheelchair design in consideration of anthropometry, physical load, control ability, posture, subjective analysis, security and so on. Korean normal adults who ever used wheelchairs are examined. And anthropometric data and basic data to make standard wheelchair are provided.

#### 국문요약

본 논문은 신체 발육이 정상 성인으로 성장한 후 후천적인 신체의 장애 즉 산업재해나 교통사고 등으로 일시적 장애자에 적합한 표준형 휠체어의 표준 규격을 설정하였다. 또한 인간공학적인 측면에서 검토분석할 수 있는 방안을 제시하여 한국인 체형에 적합한 휠체어 제작에 기여하고 또한 좀더 나은 활동으로 사용자들의 삶의 질을 향상시킬 수 있도록 하였다. 따라서 국내에서 제작 보급되고 있는 휠체어의 규격을 측정하고 본 연구에서의 인체측정치 결과와 비교분석하였으며 좌위 유지나 휠체어의 쾌적성, 보조자의 휠체어의 조작 등에서 사용자의 심리적, 감각적 평가방법을 이용하여 한국인 체형에 알맞고 인간공학적 측면에서 바람직한 표준형 휠체어를 설계하였다.

#### 1. Introduction

The functions of a wheelchair include

balancing, propelling and moving ability. Wheelchairs should be designed with the special hand-caps in mind, and be constructed with the users'

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need as the first priority.<sup>1),7)</sup> They should be comfortable and easy to operate for the users.

In the establishment of the standard for wheelchairs, the Korean Industrial Standard(KS P 6113) was established in 1976, revised in 1979 and used until today. Ten or so years have been gone since the last revision; so it is time for another revision and amendment of the standard from on the ergonomic aspect. This revision is in time for the Strategic Technique Development Project put forth by the Korean government in 1991, to be considered, by the year 2000 in the same level as the seven most advanced countries in the mechanical techniques by the year 2000. The theme of this study is going to be helpful for the technique projects for the quality of life and the economic society.

Also, this study is intended to measure the standard of the wheelchairs being manufactured and distributed in Korea today, and compare and analyze with the anthropometric measurement results, to design a standard wheelchair that suits the Korean body structure. The users' psychological and sensual evaluation method will be used for the positioning of the seat, the pleasantness of the wheelchair and the operation capability of the wheelchair by an assistant.

## 2. Scope and method

### 2.1 Scope

Wheelchairs are available in three major sizes : a standard adults size, suitable for most adults; an intermediate or junior chair for small adults and older children; and a children's size.

Except for the congenital handicaps, a standard was determined for a standard wheelchair that was suitable for normal adults with normal physical growth who acquired bodily handicaps or temporary handicaps from traffic accidents, and the anthropometric data for the standard wheelchair design were obtained through the

study conducted on the hospitalized patients at the Dong-A University Hospital.

### 2.2 Equipment and method

Among the various approaches, this study is intended to design the ergonomic wheelchair by measuring the five basic areas in a wheelchair design by using the anthropometric measurement approach used by R. Martin.

Also, the subjective evaluation method from the users' psychological and sensual evaluation method are used to evaluate the maintenance of the seat position, the pleasantness of the wheelchair, or the operation capability by an assistant.

## 3. Experiment

### 3.1 Measurement subjects

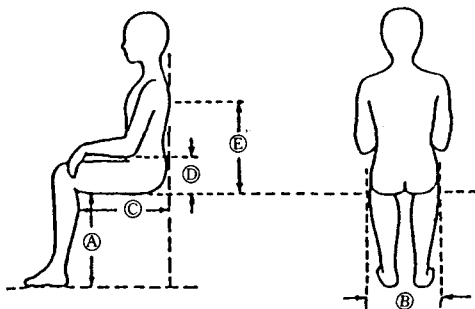
To measure the body parts necessary for the design of the wheelchair, a total of 172 hospitalized patients of the Dong-A University Hospital who used wheelchairs and received treatment at the physical therapy room were used as subjects for the experiment. 86 of them are male and another 86 are female.

To reduce the measurement error of the anthropometric measurements, two trained graduate students supervised the measurement, and the period of the experiment was about fifty days from September of 1991 to mid October of the same year.

### 3.2 Anthropometric measurement features and the results

The important elements of the chair design are generally the height, width and depth of the chair seat, which differs in accordance with the physical size of the user.<sup>3)4)6)</sup> Using the method of the Korea Standard Research Center of 1986 as a guideline, R. Martin's anthropometric measurement method was used.

The basic five areas required for a wheelchair design were measured, and the measurement areas required to express individual body structure and shape are as given in Figure 1.



- Ⓐ popliteal height
- Ⓑ hip breadth
- Ⓒ buttock-popliteal length
- Ⓓ elbow rest height
- Ⓔ bottom of scapulae height

Fig. 1 Indication of sitting measurement.

The measurement by sex for normal adults are provided in Table 1 and each measured area is indicated for male and female respectively.

Table 1 Anthropometric data of the Korean adults(unit : cm)

Part of body measured	Male (Mean±SD)	Female (Mean±SD)
popliteal height	40.2±4.7	36.3±2.9
hip breadth	34.1±2.8	33.5±2.6
buttock-popliteal length	48.7±3.9	47.1±3.8
elbow rest height	27.9±3.4	26.4±3.3
bottom of scapulae height	50.3±5.6	46.7±3.4

### 3.3 Comparison of the Korean manufacture standard and KS dimension

The standard adult wheelchairs distributed presently by the Korean manufactures A and B were measured for the five standard measurements, seat depth, width and height armrest height and the back of height. The standard was the same as in Table 2, and these data were compared with the standards used by the U.S. rehabilitation

field traditionally.

Table 2 Wheelchair dimension(unit : cm)

Dimension	Korean manufacture		American Rehabilitation
	A	B	
Seat height	45.0	46.0	48.2-50.8
Seat width	42.0	41.0	45.7
Seat depth	41.0	39.0	40.6
Armrest height	22.5	25.0	22.8-24.1
Back height	38.0	42.0	40.6-43.2

In Korea the wheelchair standard was established in December of 1976 as the Korean Industrial Standard (KS P 6113) wheelchair, and revised only once in December of 1979.

In accordance with the Industrial Standard Regulation Article 11, the Korean Industrial Standard is confirmed, amended or annualled every five years by the Korean Industrial Standard Review Board, and thus, was confirmed in 1982 and in 1987 until the present.<sup>9)</sup>

### 3.4 Results

From the above, it can be studied that there is a difference between the KS dimension and the standard adult wheelchairs manufactured and distributed in Korea.

A comparison study of the Korean manufactured wheelchairs and the KS dimension is done. The height of the seat was the same or a little higher and the seat width of the manufactured chair was 10~20mm wider than the KS dimension.

But the seat depth, armrest height and back height were all smaller than the KS dimension. Also, the seat height was 20~40mm smaller, and the armrest height was 10~50mm smaller than the KS.

In regards to the selection of the KS dimension, the advanced foreign body measurements were copied exactly and the Korean manufacturers are importing the foreign parts and putting them together.

#### 4. Determining the standard dimension

To determine the wheelchair standard, several guides for a normal chair was used as a basic. The standard necessary for the designing of a wheelchair is recommended by Everest & Jennings and Britell they are given in Table 3.<sup>2)</sup>

Table 3 Determined allowance for measuring wheelchair manufacturing(unit : cm)

Dimension	Everest, Jennings	Britell
Seat height	Ⓐ+ 5.0	Ⓐ+5.0
Seat width	Ⓑ+ 5.0	Ⓑ+5.0
Seat depth	ⓒ- 5.0	ⓒ-2.5
Armrest height	Ⓓ+ 2.5	.
Back height	Ⓔ-10.0	Ⓔ-5.0

Using the average data from Table 1 used by Everest and Jennings and the recommendation by Britell, the standard for a wheelchair for Korean adults is shown in Table 4.

Table 4 Recommended dimension of wheelchair in Korean adults(unit : cm)

part of wheelchair measured	Dimension		
	Male	Female	Average
Seat height	45.2	41.3	43.2
Seat width	39.1	38.5	38.8
Seat depth	43.7	42.1	42.9
Armrest height	30.4	28.9	29.6
Back height	40.3	36.7	38.5

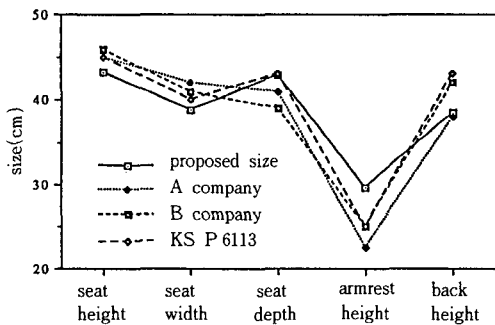


Fig. 2 Comparison between the dimension results for four wheelchair

Figure 2 shows the comparison of the wheelchair standard obtained in this study, the current-

ly manufactured wheelchairs and the KS standard.

#### 5. Ergonomic evaluation

Evaluation of the various factors such as comfort and appropriateness for the design standard should be considered for the existing chairs and the newly designed ones.

There are many methods to evaluate the chair but the ultimate standard is the subjective decision of the user,<sup>5,8)</sup> and this study applied the questionnaire method of Shackel by evaluating each part of the chair subjectively as the basis.

The proposed standard result from this study was used to alter and manufacture the existing wheelchair at the Dong-A University Hospital Medical Engineering Room to be used for subjective evaluation.

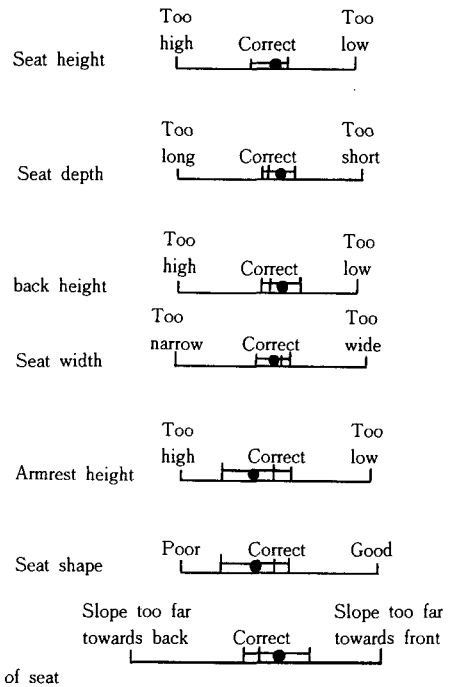


Fig. 3 The results from chair feature checklist, mean±1 SD

The results of the questionnaire for each part of the wheelchair is shown in Figure 3. The height and width of the seat are shown as relatively good, but a wide range was shown for armrest height, seat angle and seat shape.

A further study should be done for the items with a wide range of opinions, and the subjective evaluation of the assistants should be taken into considerations.

## 6. Conclusions

As an extended part of the human body, the wheelchair helps the user to participate actively and independently in daily life as well as social life by preserving the lost functions of the body. Since comfort and functional effectiveness results from the design of the wheelchair, the structure and size of the user should be taken into consideration.

The purpose of this study is to design a standard wheelchair that suits the Korean adults as follows. Standard dimensions for seat width is 39.1cm, 43.7cm for seat depth, 40.3cm for back height, 30.4cm for armrest height and 45.2cm for seat height for male, and 38.5cm for seat width, 42.1cm for seat depth, 36.7cm for back height, 28.9cm for armrest height and 41.3cm for seat height for female.

Since this study only concentrates on the anthropometric measurement that are considered as the basis for ergonomic approach methods, it is necessary to study whether the anthropometric measurement of a specific region coincides with the anthropometric measurements of all Korean adults, and further studies should be done to achieve a design that consider the burden on the living body, operating ability, posture and safety factors.

Also, it is recommended that the design of wheelchair should be considered by the professional rehabilitation team with specialists in medical, mechanical, psychosocial and especially ergonomic fields. In regards to the social welfare aspect, the surrounding environments appropriate for wheelchair usage must be provided for the user's quality of life.

## References

- 1) Frederic J. Kottke, Handbook of physical medicine and rehabilitation, W.B. Saunders Company, pp. 548~563, 1990.
- 2) Wheelchair prescription : measuring the patient, Everest & Jennings Inc., Los Angeles, Calif., 1979.
- 3) Pheasant, S., Body space : anthropometry, Ergonomics and design, Taylor & Frances, London, 1986.
- 4) Gavriel Salvendy, Handbook of Human Factors, John Wiley & Sons, New York, 1987.
- 5) C.G. Drury and B.G. Coury, A methodology for chair evaluation, Applied Ergonomics, Vol. 13, No. 3, pp. 195~202, 1982.
- 6) D.A. Hobson, J.F.M. Molenbroek, Anthropometry and design for the disabled : Experience with seating design for the cerebral palsy population, Applied Ergonomics, Vol. 21, No. 1, pp. 43~54, 1990.
- 7) R. Churchward, The development of a standing wheelchair, Applied Ergonomics, Vol, 16, No. 1, pp. 55~62, 1985.
- 8) K.S. Park, Human engineering principles of seat design, Journal of Human engineering society of Korea, Vol. 3, No. 1, pp. 25~28, 1984,
- 9) Korean Industrial Standard, KS P 6113 Wheelchairs, 1979.