

SELECTION OF AUTOMOBILES AND ASSIST DIVICES FOR PERSONS WITH PHYSICAL DISABILITIES

**Editor
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**NATIONAL REHABILITATION CENTER
FOR PERSONS WITH DISABILITIES
JAPAN**

(WHO COLLABORATING CENTRE)

December, 2004

The National Rehabilitation Center for Persons with Disabilities was designated as the WHO Collaborating Centre for Disability Prevention and Rehabilitation in 1995.

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- 1 To undertake research and development of medical rehabilitation for persons with disabilities(PWDs), and to disseminate information on the use of such technology through education and training of WHO fellows and other professional staff.
- 2 To develop training programme of self-management skill in collaboration with PWDs, and to disseminate it to relevant professionals through education and training.
- 3 To undertake studies of community-based rehabilitation(CBR), primary health care, and other social support systems for PWDs.
- 4 To undertake research and development of affordable assistive technologies in collaboration with PWDs.
- 5 To prepare manuals for education and training of professionals in health, medical and welfare services for PWDs.
- 6 To support organization of conferences and/or seminars on rehabilitation of PWDs.

National Rehabilitation Center for Persons with Disabilities

WHO Collaborating Centre for Disability Prevention and Rehabilitation

Rehabilitation Manual 15

Selection of Automobiles and Assist Devices for Persons with Physical Disabilities

December 27, 2004

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PREFACE

For persons with disabilities, moving disability is an extremely serious constraint in social participation. NRCD places strong emphasis on driving lessons for persons with various types of disability since its establishment.

The moving capability of persons with disabilities has improved using prostheses, crutches, and wheelchairs, and this has strengthened their independent living capabilities. The automobile has dramatically enhanced such obtained moving capability in social life. By driving an automobile with the hands, the living world expands by leaps and bounds. An automobile is a commodity essential to life, expanding the scope of activities and increasing the choices and the degree of freedom, and can be wings for venturing into the unknown.

This manual summarizes our years of experience in various aspects of providing automobiles fitted to the physical and mental characteristics of persons with specific disabilities and driving lessons catering for them. We hope that this manual is beneficial for a wide range of persons with disabilities.

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Introduction

This manual describes methods of selecting automobiles and assist devices implemented in National Rehabilitation Center for Persons with Disabilities to maintain safety and comfort for automobile driving by those with disabilities.

Chapter 1.

Requirements for Automobile Driving

From the viewpoint of training experience at this center, it is essential that a trainee corresponds to one of the following conditions or satisfies the corresponding conditions.

1. Conditions for Physical Capability

Since automobile driving requires precision in fast-moving complex traffic, a person with one of the following conditions may not be able to drive safely.

- 1) A person with impairment of eyesight and/or visual field
- 2) A person with impairment of gazing forward
- 3) A person with impairment of attention
- 4) A person with impairment of orientation and perception of speed and/or distance
- 5) A person with remarkable intellectual impairment and/or disorientation
- 6) A person with remarkable impairment of appreciation of the situation

2. Conditions for Assist Means to Compensate Physical Disability

Since commercial automobiles are produced for persons without disabilities, it is difficult for persons with disabilities to drive them. Many assist means have been developed to enable persons with disabilities to drive automobiles.

The assist means include: (1) Method of changing steering wheel operation force or driving posture by replacing some parts of the automobile; (2) Method of changing some operating methods or omitting some operations by installing assist devices; (3) Method of direct or indirect operation by wearing prosthesis and/or orthosis; and a combination of (1) through (3). (Automobiles with (1) and (2) are designed so that a person without disability can drive it.)

An automobile with any assist means is required to have the capability so that the main devices, such as the steering wheel, brake pedal, and throttle pedal, can be directly or indirectly operated at will and the capability to "run, turn, and stop" according to the traffic rules. In general, a person who corresponds to one of the following conditions may not be able to drive safely.

- 1) A person who cannot maintain a driving posture
- 2) A person who lost all four limbs or all of their functions

- 3) A person who has remarkably weak operation force
- 4) A person who has remarkably restricted range of joint motion
- 5) A person who lost voluntary control of his or her body
- 6) A person who cannot control his or her force
- 7) A person who has difficulty in coordination of his or her limbs motion
- 8) A person who has remarkably slow movement
- 9) A person who cannot get in or out of the automobile by himself or herself

Chapter 2.

Automobiles and Assist Devices for Driving

1. Automobiles

Since automobiles are produced based on the physical capabilities of persons without disability, it is difficult for persons with physical disabilities to drive automobiles. To compensate the capabilities of persons with weak muscles or restricted range of joint motion, some parts of automobile are replaced.

It is necessary to select an automobile that can fit the remaining capabilities as much as possible in advance by understanding the characteristics of commercial automobiles.

1) Driving Seat

Height and the distance of the seating surface: The height of the seating surface and the distance between the driving seat door and the edge of the driving seat should be considered. A person with paraplegia may not be able to safely get in or out when the seating surface is too high or the seat edge is too far from the door.

Shaped of the Seats: There are two types of seat shape, flat type and side support type. Flat type is preferred for horizontal moving in automobile and side support type is preferred for stable driving position. Fig.1 shows an example for persons with paraplegia to improve both ease of getting in and out, and posture support while driving. The side support goes down to horizontal position and the gap between the wheelchair and the driving seat is minimized. The angle of the backrest can be adjusted to make the driver's back be in contact with backrest. It enables not only maintaining the gap between the head and the headrest, but also greater support of driving posture and operability of the main driving devices. The seat surface can be easily replaced by the silicone rubber seat surface designed for urinary incontinence or preventing pressure sores.

Booster Seats: A booster seat to elevate a seat level is required for a person with short stature or low seated height to make sure visibility and operability. It is essential to secure the booster seat and the stability of the driver.

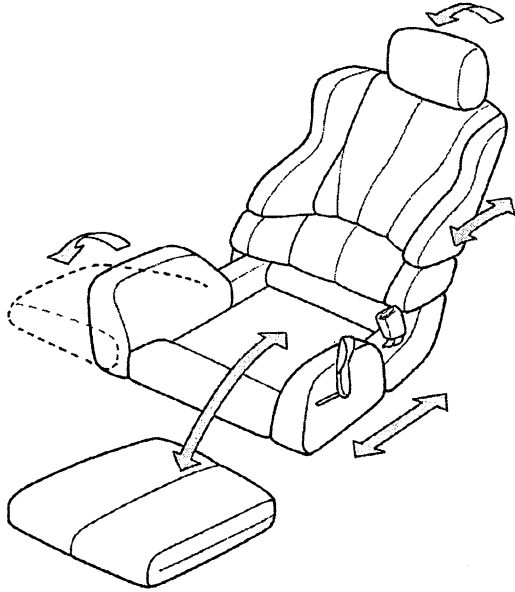


Figure 1 Driving seat for persons with disabilities

2) Steering Wheel

In order to ensure safety and comfort while driving, it is essential to enable operation of the steering wheel at will. Even when method of operation is changed due to disability, the following conditions are required.

- (1) The driver can turn the steering wheel two revolutions clockwise and counterclockwise from a straight-forward position.
- (2) The driver can turn the steering wheel as above within 2.5 sec. in each direction for quick operation.
- (3) The driver can turn the steering wheel continuously.

3) Throttle and Brake

The positions of the throttle and brake pedals of commercial automobiles are determined so that person without disability can easily operate them with the right foot. The operating force of the throttle pedal is approximately 30-50N, and does not vary greatly depending on the type of automobile. On the other hand, the operating force of the throttle pedal is set within an approximate range from 160 to 450N when their antilock braking systems are in operation on a dry road, and varies greatly depending on the type of automobile. A person who has muscle weakness of lower extremity needs to select an automobile with small main braking force (force on the pedal required to generate deceleration of 6.43 m/s^2).

In order to ensure safety and comfort while driving, it is essential to enable the operation of the throttle and brake pedal at will. Even when the method of operation is changed due to disability, the following conditions are required.

- (1) The reaction time from the throttle pedal to the brake pedal is 0.6 sec. or shorter.
- (2) The driver can reliably operate the brake pedal.
- (3) The driver can control the braking force and obtain deceleration of 10 m/s^2 or more for a quick stop.

4) Seatbelt

Although a seatbelt is an arresting device effective for protection of the occupant at collision, it may be dangerous, such as causing rupture of visceral organs if not properly loaded. Adjust the height with adjustable seatbelt anchors so that the shoulder belt is positioned around the center of the clavicle when loaded. Adjust the waist belt to a lower position around the pelvis, not the abdomen. Because a short person or a person with low seated height is mismatched for the loading position using only the height adjustment of the shoulder belt, it is better to install the four-point type.

5) Airbag

This is an checking device to assist the seatbelt and operates at high impact from the front to protect the head and chest. If a person with shorter four limbs sits extremely close to the steering wheel for driving, he or she may be bounced by the airbag when it is inflated, and injured. Extending the driving devices will reduce the risk of injuring by inflating air bag.

6) Automatic Transmission

This is effective as a method to eliminate gear change operation when driving. Because of recent technological innovation, the difference in motive performance and mileage between automatic and manual transmission is becoming smaller. It is better for persons with disabilities to select an automobile with automatic transmission.

2. Assist Devices for Driving

Persons with limb dysfunction are required to have ability to move at least two limbs at will, one limb to handle a steering wheel and another to operate throttle and brake devices. Devices available to assist operating driving apparatus are those for steering wheel, throttle and brake, direction indicator, headlight control, wiper, select lever, parking brake, foot-operated steering wheel and lift for wheelchair.

1) Hand-operated Devices

These are mainly used by paraplegic persons. There are two types, the floor type (Fig. 2) and the column type (Fig. 3).

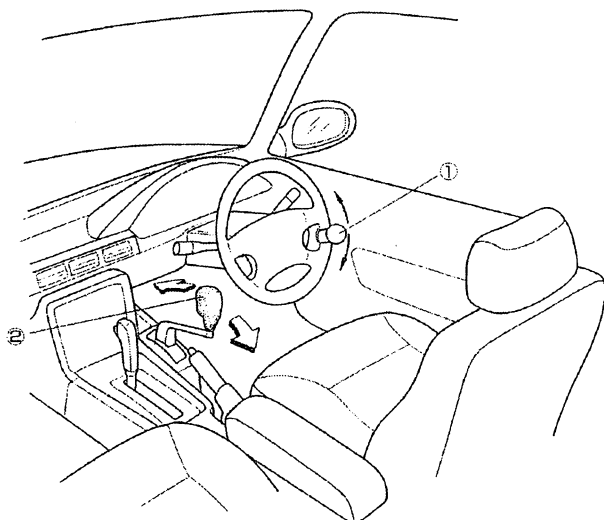


Figure 2 Floor-type hand-operated device

① Knob-type steering device

② Floor-type steering device

-For braking operation, push the entire lever forward.

-For throttle operation, pull the entire lever backward.

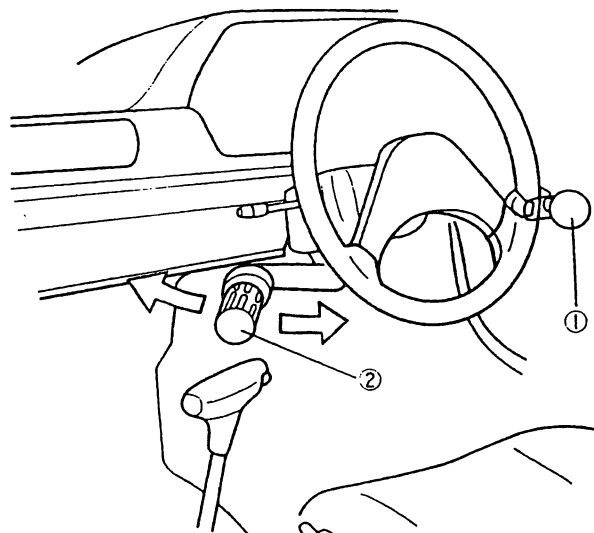


Figure 3 Column-type hand-operated device

① Knob-type steering device

② Column-type steering device

- For braking operation, push the entire lever forward.

- For throttle operation, there are two types; the type to pull the entire lever backward and the type to pull the grip only backward

(1) Floor Type

This type has a control lever located next to the gear lever in line for braking by pushing it forward and throttling by pulling it backward. Therefore, forwarding acceleration of the driver when the automobile is decelerating naturally operates to the braking direction. The feature of the floor type is that the supporting point of the device is fixed to the floor of the driving seat, facilitating maintaining seating balance at curves or corners. The floor type is suitable for those with spinal cord injury with unstable seating balance, persons with trans-femoral amputations who use lower extremity prosthesis for driving, and persons who have restricted range of joint motion.

(2) Column Type

This type has a control lever located at the front of the steering wheel for braking by pushing it forward and throttling by pulling it backward.

A feature of the column type is that the supporting point of the device is fixed to the steering wheel post. The column type is suitable for persons with both trans-femoral amputations, while driving without prosthesis.

The auxiliary switches such as the direction indicator switches, brake lock switch, and horn switch are mounted on both the floor type and the column type.

2) Steering Device

There are 8 types of devices to help gripping steering wheel for persons with upper limb dysfunction. These devices are either mounted on the top or at the inner position of the wheel. Those mounted on the top are suitable for persons whose driving posture are unstable and /or steering power are weak.

(1) Hand Drum-type Steering Device

This is used by persons who can grip a small bar using the palm and fingers. The driver directly grips the steering wheel when driving straight and uses the bar only when turning (Fig. 4).

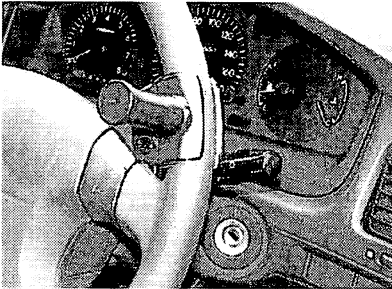


Figure 4 Hand-drum-type steering device

(2) Knob-type Steering Device

This is used by persons who can grip a tennis ball, etc. using the palm and fingers. (Fig. 5 and 6).

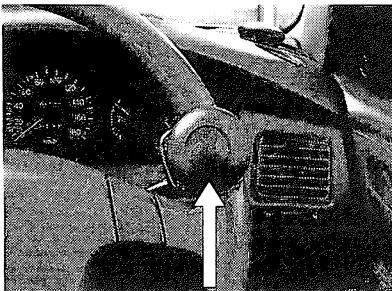


Figure 5 Steering device

Knob type (top view)

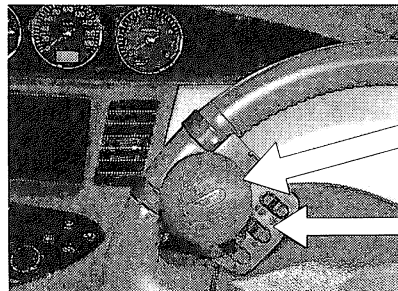


Figure 6 Steering device and direction indicators

(3) Horizontal Bar-type Steering Device

This is used by persons who have enough power to move the wrist joint and can grasp the bar using the fingers, but cannot grip it using the palm and fingers (Fig. 7).

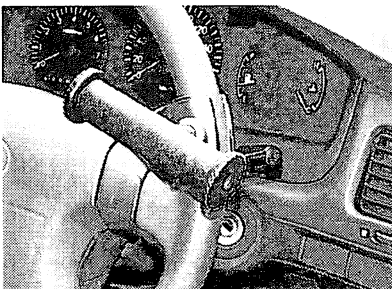


Figure 7 Horizontal bar-type steering device

(4) Vertical Bar-type Steering Device

This is used by persons who have enough power to move the wrist joint and can grasp objects using the fingers, but cannot grip it using the palm and fingers. Because this device may incur risk of injury to the driver's head, chest, and abdomen at collision, it is preferable to limit the use of this device as much as possible (Fig. 8).

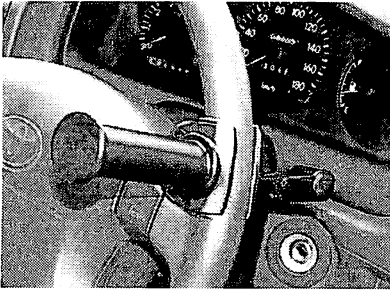


Figure 8 Vertical bar-type steering device

(5) Vertical Palm-type Steering Device

This is used by persons who can move the wrist joint, but cannot move the fingers. This device can be easily operated by moving the center of gravity of the trunk from side to side, but the driving posture may become unstable if the person has unstable seating balance (Fig. 9-1 and 9-2).

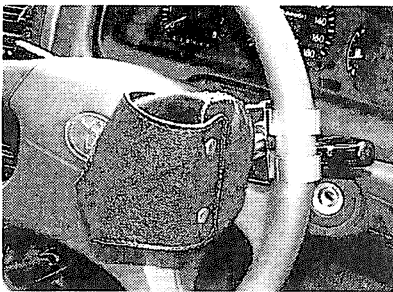


Figure 9-1 Vertical palm-type steering device

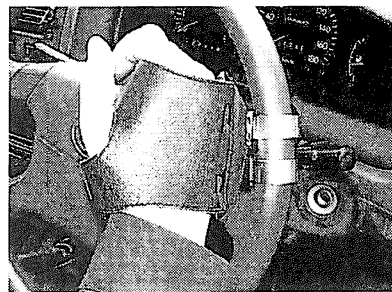


Figure 9-2 Vertical palm-type steering device

(6) Horizontal Palm-type Steering Device

This is used by persons who can move the wrist joint, but cannot move the fingers. When a device with a fixing belt is used, the driver's upper limbs may be injured when the airbag is inflated at collision (Fig. 10-1 and 10-2).

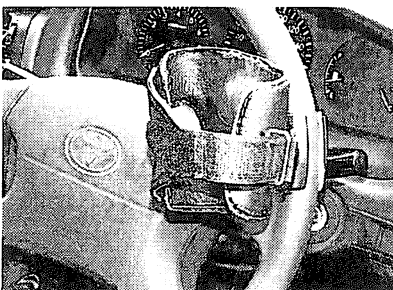


Figure 10-1 Horizontal palm-type steering device (with fixing belt)

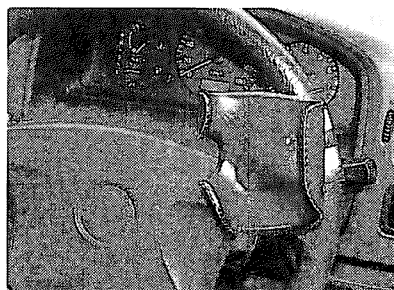
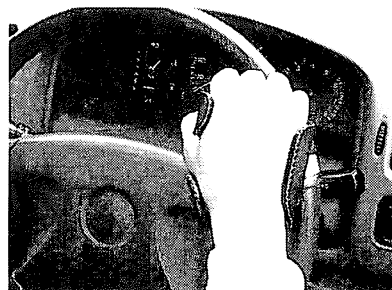


Figure 10-2 Horizontal palm-type steering device (without fixing belt)



(7) U-type Steering Device

It cannot be used by persons who have no grip power because they may fall while steering (Fig. 11-1 and 11-2).

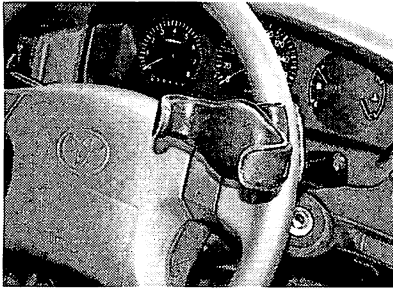


Figure 11-1 U-type steering device



Figure 11-2 U-type steering device

(8) Ring-type Steering Device

This is used by persons who use a body-powered upper limb prosthesis due to trans-radial amputation. (Fig.12).

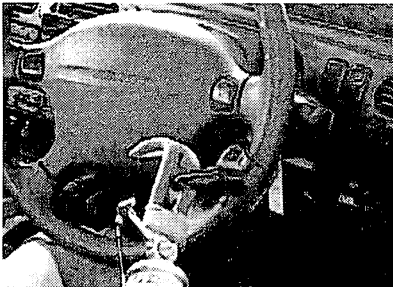


Figure 12 Ring-type steering device

There are two types of steering device in terms of position of the grip on steering wheel; the type with the grip mounted on top of the wheel (Fig. 5) and the type with the grip mounted at the inner position of the wheel (Fig.6). Because the grip is mounted on the top of the wheel for the former, it can be operated by the steering force originally designed for automobiles and selected by those who have unstable driving posture or weak steering force. Because the grip is mounted at the inner position of the wheel, some devices can be detached, and a 15% stronger steering wheel is required. This is selected by persons who have no problems with driving posture and/or when family members mainly drive the automobile.

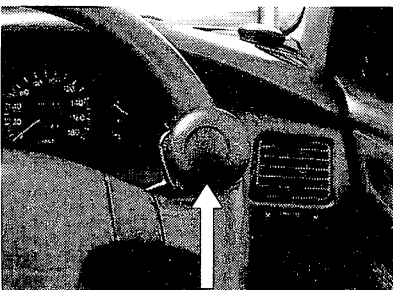


Figure 5 Steering device

Knob type (top view)

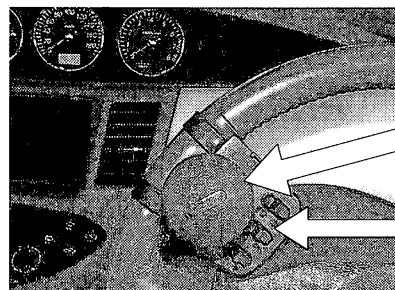


Figure 6 Steering device and direction indicators

3) Operation Mistake Protection Devices for Throttle and Brake Pedals

These are used by persons who extend or bend the lower limbs involuntarily due to spastic limbs or flaccid paralysis. Because the throttle and brake pedals are functional even when operated by the upper limbs using a hand-operated device, operation mistakes such as inserting the foot under the pedals or stepping on them can be prevented. These include installation of a shield plate short of the pedals (Fig. 13) and a method to flipping up the pedals (Fig.14). A person with a big build or unstable seating balance should select the flip up pedal method since the lower limbs extend forward, and the space around the feet becomes extremely small if the shield plate is selected.

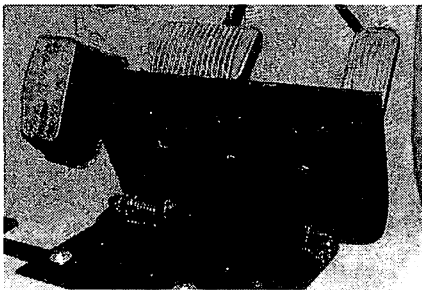


Figure 13 Operation mistake protection devices for throttle and brake pedals (Shield plate)

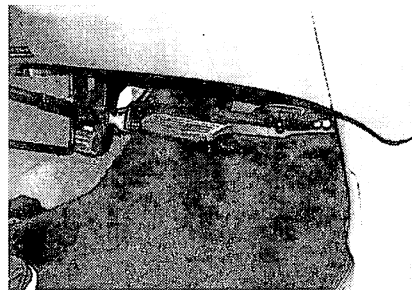


Figure 14 Operation mistake protection devices for throttle and brake pedals (Flip up type)

In addition, a person whose femoral region is in contact with the steering wheel when the lower limbs are bent uses the seatbelt for the lower limbs.

4) Throttle Pedal Device for Left Foot Operation

This is mainly used by persons who have an impairment on right foot. A new pedal is additionally installed for the left foot so that the throttle pedal can be easily stepped on. There are two types, the hang type (Fig. 15) and the stand up type on the floor (Fig.16), and their switching methods between the existing pedal and the throttle pedal for left foot operation are different. Because some stand up pedals on the floor are the same height as the brake pedal, or there is a smaller gap between the pedals, they may cause operation mistakes. In addition, as operability is poor for a person who has unstable seating posture and operates it with his or her heel in contact with the floor, the hang type should be selected.

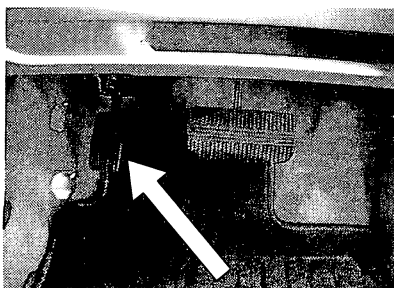


Figure 15 Throttle pedal device for left foot operation (Hang type)

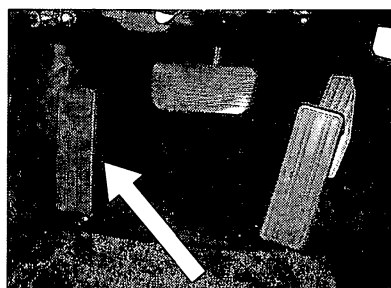


Figure 16 Throttle pedal device for left foot operation (Stand up type)

5) Assist Device for Direction Indicator

There are two types of assist device for direction indicator, extension lever for the existing direction indicator (Fig.17) and remote control type (Fig. 5). The latter is recommended.

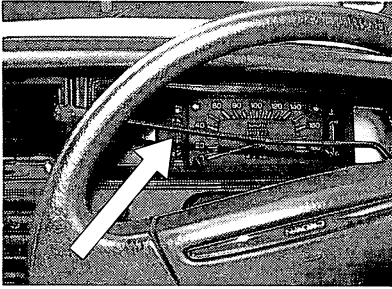


Figure 17 Assist device for direction indicator

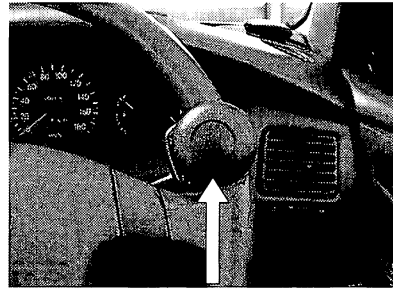


Figure 5 Steering device Knob type (top view)

6) Assist Device for Headlights (Auto-light)

As automobiles equipped with an auto-light are available, it is recommended for persons with disabilities to buy an automobile with auto-light. The assist devices to automatically turn the headlights on and off are also available.

7) Wiper Assist Device

It is preferable for persons with impairment on upper limb to buy an automobile equipped with an automatic wiper. An extension lever for easy operation of wiper lever is also available.

8) Assist Device for Select Lever (Fig. 18)

For persons unable to push the button on the select lever, a device to help pushing the button can be retrofitted. Check the operability, the shape of the lever and the mounted position so that the driver is injured in accident.

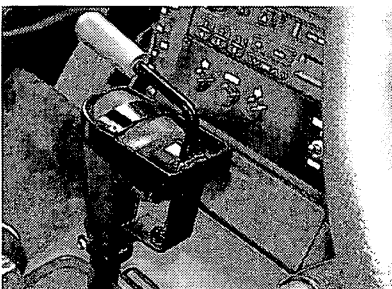


Figure 18 Assist device for select lever

9) Assist Device for Parking Brake

(1) Assist device for hand-operated parking brake(Fig. 19-1)

This is retrofitted on hand-operated parking brake to assist operating parking brake.

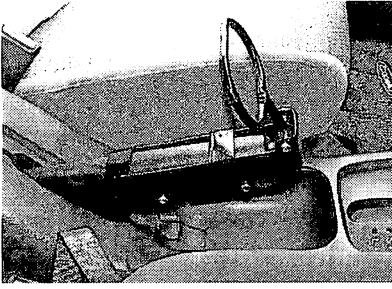


Figure 19-1 Assist device for parking brake

(2) Assist device for foot -operated parking brake (Fig. 19-2).

This device is used to operate foot-operate parking brake pedal by hand.

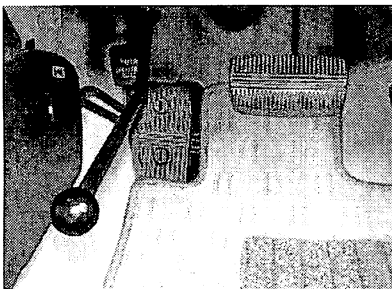


Figure 19-2 Assist device for parking brake

10) Foot-operated Pedals to Operate Steering, Throttle, Brake Pedal and Select Lever (Fig.20).

This is used for persons with both upper extremities dysfunction.

Drivers operate the steering pedal by turning it like bicycle pedal with left foot and operate the throttle,

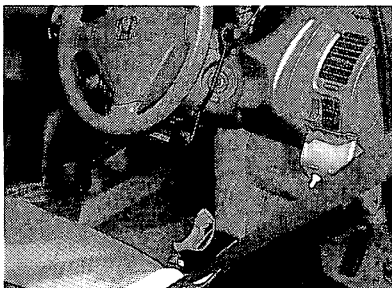


Figure 20 Foot-operated device

11) Lift for Wheelchair

(1) Assist device to place an wheelchair on the roof (Fig. 21)

(2) Assist device to house wheelchair on the rear seat (Fig. 22)

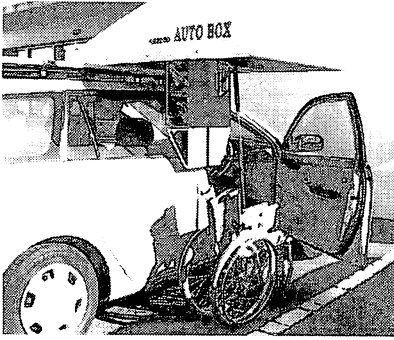


Figure 21 Lift for wheelchair
(Type for placing on roof)



Figure 22 Lift for wheelchair
(Type for housing inside the automobile)

Chapter 3.

Methods of Selecting Automobiles and Assist Devices for Driving, and Notes for Driving

1. Methods of Selecting Automobiles

Select automobiles with automatic transmission and assist means can be easily installed.

By fitting the basic performance of the automobile to the physical abilities of the driver, safety and comfort can be secured. In addition, reducing the number of parts to be modified is cost effective. Specific points are described below:

- 1) Checking Ease of Getting in and out
- 2) Checking the Loading and Unloading of the Wheelchair

For easy loading and unloading, order the automobile to be manufactured under the following conditions. In addition, for a person who cannot load or unload a wheelchair by himself or herself, select a lift for the wheelchair.

- (1) Tire diameter of 22 inches or less
- (2) Weight of 12 Kg or lighter
- (3) Backrest height of 38 cm or lower
- (4) Easy folding operation

3) Checking the Driving Posture

- (1) the driver can sit on the driving seat
- (2) the driver can assume the driving posture by adjusting the driving seat
- (3) the eye point is maintained
- (4) As a practical measure, check that the driving posture can be maintained by pushing the driver's shoulder from side to side and forwards and backwards.

4) Checking the Operability of the Steering Wheel

- (1) Operate the steering while the automobile stopped

(2) Check that the driver can operate the steering wheel maintaining the correct driving posture even when driving slowly or at medium speed

5) Checking the Operability of the Brake

(1) For a person who operates the brake pedal with the lower limbs, measure the person's maximum stepping force, staying power, and pedal change time. When the person has problems such as weak stepping force or staying power, longer pedal change time, unstable pedal stepping position, and stepping fault, braking operation with the upper limbs needs to be considered.

(2) For a person who performs the braking operation with the upper limbs, measure the person's maximum stepping force, staying power, and reaction time. When the person has problems such as weak pushing force or staying power and longer reaction time, braking operation may be difficult.

2. Amputation

1) Trans-radial Amputation

When a person with a long stump or a short stump operates the steering wheel using a myoelectric or body-powered upper limb prosthesis, the person can operate the steering wheel by installing a steering device matched with the terminal device.

Steering operation with an upper limb prosthesis may not be qualified for a person with a short stump in some cases.

2) Trans-humeral Amputation

Considering the functions of a trans-humeral prosthesis when used only for driving, it is difficult to operate the steering wheel, throttle pedal and brake pedals.

3) Trans-tibial Amputation

A person with a long stump can operate the throttle, brake, and clutch pedals if adaptability to the prosthesis is good. In particular, a person with a shorter medium stump or a short stump may not be able to step on a pedal accurately when switching the pedals quickly. In this case, a hand-operated device should be used to operate the throttle and brake pedals.

4) Trans-femoral Amputation, Hip Joint Disarticulation and Hemipelvectomy

For a lower limb with a trans-femoral prosthesis attached, it is difficult to directly operate throttle pedals, brake and clutch due to lack of operating force, quickness, and precision. Hand-operated device is necessary to operate them.

Persons with trans-femoral amputation(except long stump),hip-joint disarticulation and hemipelvectomy need to use prosthesis normally they use to keep stable posture during steering.

3. Cervical Cord Injury

1) Methods of Selecting Automobiles

To operate an automobile, it is required to have a remaining nervous function at C6 level and higher segment of the spinal cord by the ASIA grade.

Methods of selecting automobiles

- (1) The steering force is approximately 13N or lower.
- (2) For the braking force, the stepping force required to generate deceleration of $N/6.5 \text{ m/s}^2$ is approximately 110N or less (check in the specifications of the automobile).
- (3) The seat surface height of the driving seat is approximately 50 cm or lower.
- (4) It is better to use a driving seat for those with disability with better posture-holding performance or an automobile equipped with a driving seat with better posture-holding performance. In addition, select a motor-driven adjustment for the seat because it needs to be adjusted each time the person gets in or out, and each time the wheelchair is loaded and unloaded.

2) Method of Selecting Assist Devices for Driving

(1) Hand-operated device

Select a floor-type hand-operated device with a T-type grip for improved operability and a shape designed for the free operation of the auxiliary switches such as the direction indicators, brake lock, etc.(Fig.2)

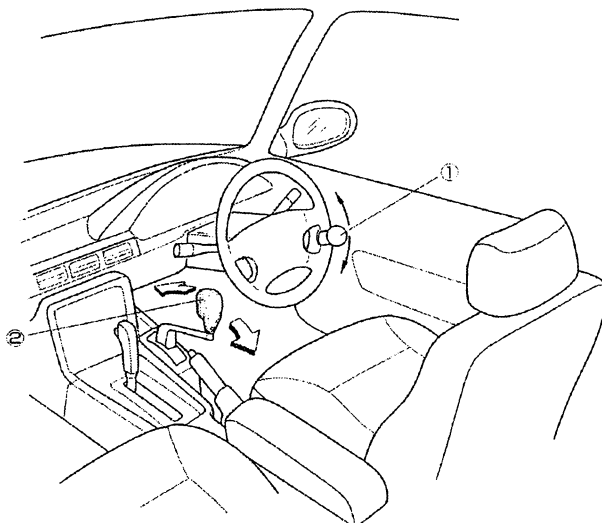


Figure 2 Floor-type hand-operated device

① Knob-type steering device

② Floor-type steering device

-For braking operation, push the entire lever forward.

-For throttle operation, pull the entire lever backward.

(2) Steering device

Select a horizontal palm-type steering device with the grip mounted on the top of the steering wheel.(Fig.10-2)

It is better to manufacture a steering device matched with the palm size of each user.

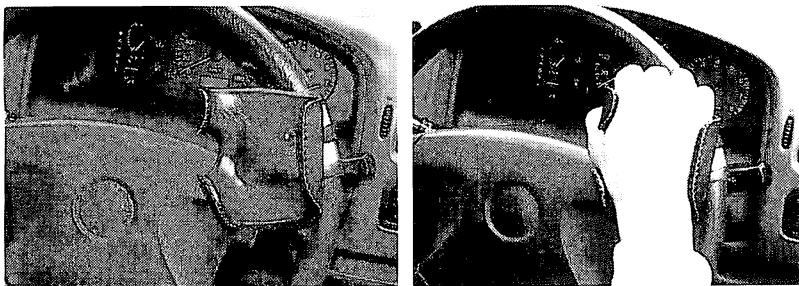


Figure 10-2 Horizontal palm-type steering device
(without fixing belt)

(3) Others

A person who shows spastic involuntary motion requires a device to protect against mistakes in operating the throttle and brake pedals, and a person whose right hand is fixed on the steering wheel requires an auto-light.(Fig.14) In addition, when using the step-type parking brake or depending on the shape of the select bar, additional protect equipment is necessary. For a person who has difficulty in loading and unloading an wheelchair, select a loading device to put the wheelchair outside the automobile (on the roof).

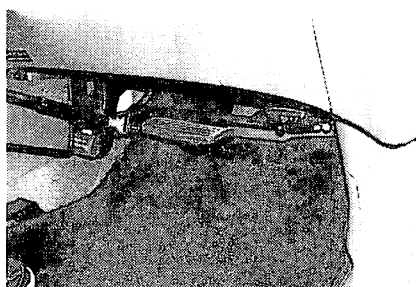


Figure 14 Operation mistake protection
devices for throttle and brake pedals
(Flip up type)

3) Notes for Driving

- (1) Pushing up is required to prevent bedsores on the hip.
- (2) To keep stable posture during driving, it is preferable for the person to be trained to get in and out by a physical therapist.
- (3) It is necessary to care not get injury when the person gets in or out and loads or unloads the wheelchair.
- (4) Because such a person has hypohidrosis of the paralytic part, body temperature regulation is insufficient in the summer. It is necessary to use an air conditioner to control the temperature inside the automobile in summer season.
- (5) Such a person may have symptoms such as increased blood pressure, headache, face flush, and anxiety due to autonomic hyperreflexia. It is necessary to empty the bladder before driving to prevent autonomic hyperreflexia.
- (6) Such a person may have symptoms such as pallor of the face, impaired consciousness, and delirium a-

nimi due to orthostatic hypotension. Instructor have to advice of temporal treatment and body position when the symptom appeared.

4. Thoracic Cord and Lumber Cord Injury

1) Methods of Selecting Automobiles

Basically, select an automobile that the driver can get in and out of, and load and unload the wheelchair. For a person who has weak operating force of the steering wheel or brake, who has unstable seating balance, or who has difficulty in getting in and out, select an automobile according to the standard as described in section 1) for cervical cord injury.

2) Method of Selecting Assist Devices for Driving

(1) Floor-type hand operated device

May select any grip type; T-type or knob type grip.(Fig.2)

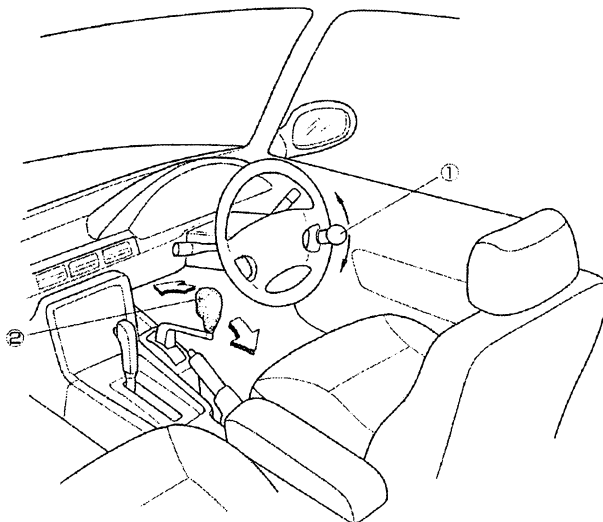


Figure 2 Floor-type hand-operated device

① Knob-type steering device

② Floor-type steering device

-For braking operation, push the entire lever forward.

-For throttle operation, pull the entire lever backward.

(2) Steering device

Select a steering device of the hand-drum type or the knob type.(Fig.4,5)

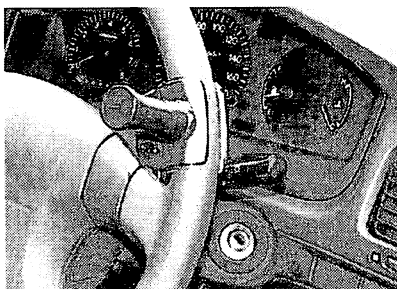


Figure4 Hand-drum-type steering device

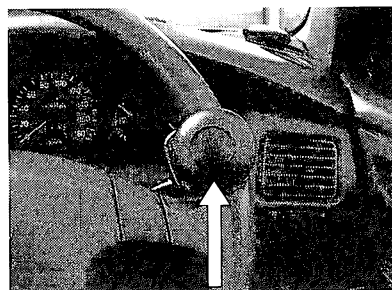


Figure 5 Steering device Knob type (top view)

(3) Others

Select a device to protect against operation mistakes for the throttle and brake pedals due to spastic involuntary motion.(Fig.13)



Figure 13 Operation mistake protection devices for throttle and brake pedals (Shield plate)

5. Cerebral Vascular Diseases

1) Methods of Selecting Automobiles

Select an automobile that the driver can get in and out of , load and unload the wheelchair and equipped hand-operated parking brake.

2) Method of Selecting Assist Devices for Driving

(1) Persons with left hemiplegia

Select knob type steering device(Fig.5) and remote control type direction indicator(Fig.6).

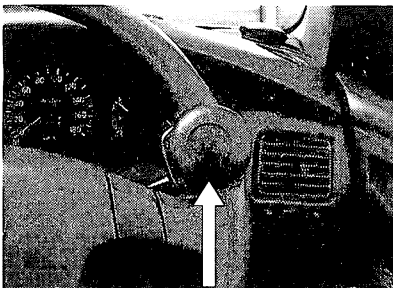


Figure 5 Steering device

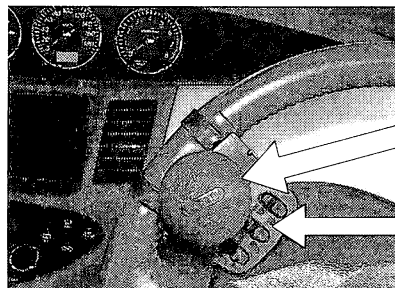


Figure 6 Steering device and direction indicators

(2) Persons with right hemiplegia

Select knob type steering device(Fig.5) and remote control type direction indicator(Fig.6), auto-light, hang type throttle pedal device for left foot operation(Fig.15).

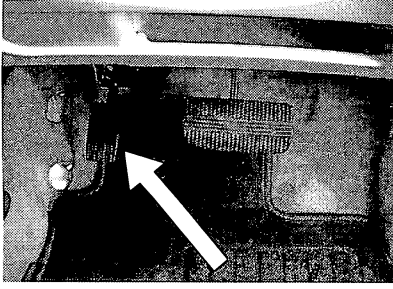


Figure 15 Throttle pedal device for left foot operation (Hang type)

3) Notes for Driving

Following persons with symptom are recommended not to drive automobiles.

- (1) Persons who are often induced a symmetric tonic neck reflex.

Such persons may mistake to operate steering wheel and throttle pedal due to reflective movement of limbs at checking safety and changing direction.

- (2) Persons have strong symptoms of dementia, aphasia, agnosia, alexia, hemineglect and hemianopsia.

- (3) Persons with attention impairment.

Chapter 4.

Procedure of Automobile Driving Lessons

1. Contents of the Driving Ability Tests

To maintain safety and comfort while driving, assessment of driving abilities is conducted.

1) Assessment with Driving Aptitude Test Equipment

Mental tests with test equipment, etc. performed in stationary conditions are as follows:

- (1) National Police Agency formula driving aptitude test K2
- (2) National Police Agency formula CRT test
- (3) Action decision test
- (4) Eye test
- (5) Dynamic eye test
- (6) Perimetry
- (7) Night vision test
- (8) Depth perception test
- (9) PET (Positron Emission computed Tomography) test

2) Assessment of Operating Force, etc. with Instruments

For the tests in stationary conditions, the basic operating forces required for driving such as pushing,

pulling, turning, and stepping forces are measured using an automobile equipped with instruments and simulator machines, and the method of driving is assessed.

(1) Operating ability of steering

The operating force, operating time, controlling force, and endurance are measured and assessed.

(2) Operating ability of throttle and brake

For operation with the lower limbs, the stepping force, reaction time, accuracy of stepping position, controlling force, and staying power are measured and assessed.

For operation with the upper limbs, pushing force, pulling force, reaction time, controlling force, and staying power are measured and assessed.

3) Assessment of Adaptability for Driving

The adaptability of the driver, the automobile, and the assist devices is actually assessed using the automobile under stopping and driving conditions using the Test Drive Assessment Table (Table 1).

Table 1 Test Drive Table

	Item to be checked	Evaluated		Item to be checked	Evaluated
1	Unlock the door lock from the outside	OK Difficult NG	18	Operate the light switch	OK Difficult NG
2	Open the door from the outside	OK Difficult NG	19	Operate the wiper	OK Difficult NG
3	Get in	OK Difficult NG	20	Operate the horn	OK Difficult NG
4	Load the wheelchair	OK Difficult NG	21	Open and close the windows	OK Difficult NG
5	Close the door from the inside	OK Difficult NG	22	Open the door from the outside	OK Difficult NG
6	Lock the door from the inside	OK Difficult NG	23	Get out	OK Difficult NG
7	Move the driving seat forward	OK Difficult NG	24	Unload the wheelchair	OK Difficult NG
8	Move the driving seat backward	OK Difficult NG	25	Close the door from the outside	OK Difficult NG
9	Adjust the angle of the driving seat backrest	OK Difficult NG	26	Lock the door lock from the outside	OK Difficult NG
10	Adjust the room mirror	OK Difficult NG	27	Operate the steering wheel (stationary steering)	OK Difficult NG
11	Adjust the door (fender) mirrors	OK Difficult NG	28	Operate the throttle	OK Difficult NG
12	Fasten and release the seatbelt	OK Difficult NG	29	Operate the brake	OK Difficult NG
13	Start and stop the engine	OK Difficult NG	30	Operate the clutch	OK Difficult NG
14	Operate the select lever	OK Difficult NG	I	Quick braking	OK Difficult NG
15	Operate the side brake	OK Difficult NG		Seating posture balance	OK Difficult NG
16	View site (view site range to front, rear, and right/left sides)	OK Difficult NG	II	Operate the steering (during drive)	OK Difficult NG
17	Operate the indicators	OK Difficult NG	III	Seating posture balance on curved road	OK Difficult NG
Comment	Date: _____, Name of the automobile used: _____				
	Signature				
About selection of automobile and assist devices for driving, and prosthesis and orthoses					Training method

【Evaluation】

OK: The driver can perform safely and smoothly.

Difficult: The driver can perform but not safely and smoothly.

NG: The driver cannot perform.

4) Assessment of Basic Sensing

Running position sensing, speed sensing, direction sensing, etc. are assessed actually using the automobile under stopping and driving conditions.

- (1) For a person who is newly obtaining a license, the following points are assessed: ① whether the person can recognize the orientation of the automobile relative to the running direction, ② whether the person can recognize that the speed is slow or fast, ③ whether the person can recognize the width and length in

the running direction, and the running position of the automobile, ④ whether the person can recognize that the road is wide or narrow, ⑤ the person can recognize the distance from the turning points and obstacles, and ⑥ the person can recognize that the automobile is running straight (Table 2).

Table 2 Basic Sensing Capabilities for Driving (for a person who is obtaining the driving license)

	Item to be assessed	Issue to be assessed
1	Direction sensing (at stop)	Can the driver recognize the orientation of the automobile such as straight, right, or left, slight sloping?
2	Speed sensing	Can the driver recognize the difference between slow and fast? Can the driver return to the instructed speed after changing it?
3	Automobile sensing	Can the driver recognize the size of the automobile? Can the driver guide the automobile to the center, right side, and left side of the road?
4	Position sensing	Can the driver recognize the front/rear and right/left positions relative to the marks or objects? Can the driver recognize the position relative to the centerline, curbstones, poles, and stop line?
5	Distance sensing	Can the driver recognize distances of 30 m, 5 m and 1 m from the crossing or target?
6	Straightness sensing (while driving)	Can the driver recognize that the automobile is running straight on straight road?

(2) For a person who already has a license, in addition to the items in (1) above, the following points are also assessed: ① whether the person can start and stop the automobile safely, ② whether the person can indicate the direction for making a left or right turn, and change direction, ③ whether the person can check for safety at crossings, etc. ④ whether the person can maintain the running direction on straight and curved roads, and ⑤ whether the person can choose the speed according to the site (Tables 3-1 and 3-2).

5) Assessment of Language Capability Concerning Traffic

Using a written examination, the acquired level of language concerning traffic is assessed.

Table 3-1 Basic Sensing Capabilities for Driving (For a person who has the driving license already)

	Item to be assessed	Issue to be assessed (Item to be observed)	Date:		
			Points	Total	Judge
1	Start and stop	① Can the driver go forward and backward, and park? (Observe the following points: Can the driver understand the procedure? Can the driver operate the select lever after operating the brake pedal? Does the driver forget to operate the select lever?)	0 1	points	0 point :Rejected 1 point: Passed
2	Indication	② Does the driver turn on the indicators when starting and parking? (Observe that the driver turns on the indicators when starting or parking.) ③ Does the driver turn on the indicators when making right and left turns? (Observe that the driver does not forget to turns on, not the timing to turn on.) ④ Does the driver turn on the indicators when changing direction? (Observe that the driver does not forget to turn them on, observing the time to the turning them on.)	0 1 0 1 0 1		1 point or less : Rejected 2 points or more: Passed
3	Safety check and range	⑤ Does the driver check safety by direct visual check or using the mirror when starting? (Observe that the driver does not forget the safety check and that the driver checks immediately before starting.) ⑥ Does the driver check right and left at crossing? (Observe the following points: Does the driver not forget the safety check on right and left turns? Does the driver check the right direction when turning or curving right, and the left direction when turning or curving left? Does the driver have anticipating eye point?) ⑦ Can the driver pay attention to the right and left sides while gazing ahead? (Observe that the driver can align the front end of the automobile or the driving seat with a marking pole, etc. located at right or left side while gazing ahead.)	0 1 0 1 0 1	points	1 point or less : Rejected 2 points or more: Passed
4	Running position sensing	⑧ Can the driver always drive on the left side? (In particular, observe that the driver does not drive on the right side after making a right or left turn, or passing through a narrow road.) ⑨ Can the driver park the automobile left edge of the road? (Observe that the driver can pull the automobile over without running off or making the wheel make contact with the curbstone because of not using the mirrors while gazing ahead.) ⑩ Can the driver drive the automobile on the left edge of the road straight at speed or 30km/h or faster? (Observe that the driver can drive the automobile straight on the left edge without running off, maintaining contact of the wheel with the curbstone, or swinging not using mirrors while gazing ahead.) ⑪ Can the driver maintain a distance from obstacles on right and left sides? (Observe that the driver can maintain a distance of 1 m and 2 m from three-dimensional obstacles while gazing forward.) ⑫ Is running position stable when making right or right, or curving? (Observe that the driver does not make big turn or small turn and that the running position does not become greatly irregular on the same curved road.) ⑬ Does the driver change the direction when making right and left? (Observe that the driver does not forget to change the direction, not change the direction before indication, and that the driver can perform the series of actions from indication, confirmation, and changing the direction.) ⑭ Can the driver maintain the stable direction after changing the direction? (Observe that the pulling over is stable, that the driver can maintain the running position without swinging.)	0 1 0 1 0 1 0 1 0 1		3 points or less : Rejected 4 points or more: Passed
5	Driving speed	⑮ Can the driver drive the automobile at closely determined speed according to the driving site? (Observe that the speed is not too slow, that the driver accelerate the automobile on straight road, that deceleration is not be delayed when approaching corner to turn to left or right, curve, or narrow road, and that the driver can maintain the speed.)	0 1	points	0 points Rejected 1 points Passed
Synthetic judgment All points are added as 1 point for “Yes” and 0 point for “No.” It is judged as one of the five levels using total points on the passed items to be assessed as follows: 1 point or less: Severest 2 points: Severe 3 points: Medium 4 points: Light 5 points: No problem					

Table 3-2 Notes for assessment of basic sensing capabilities for driving of persons with brain dysfunction

1. Targeted persons

- (1) Persons without severe higher brain dysfunction.
- (2) Persons who are almost independent on daily life.
- (3) Persons who can understand explanation on issues to be assessed.

2. About points

- (1) If a person has any problem on a issue to be assessed and the problem can not be resolved with guidance and advice within one hour, the point is zero.
- (2) If a person has no problem on a issue to be assessed and any problem is resolved with guidance and advice within one hour, the point is one.

3. Note

A person should not be assessed based on the driving skill or rating reference of the test drive, but assessed objectively on the result whether the action can be performed by the person, or not.

2. Contents of Automobile Driving Lessons

1) Courses on Rules

In the courses on rules, a specific range of traffic rules defined in the Road Traffic Law are learned,

- (1) Traffic rules defined in law
- (2) Items required to prevent danger and other items required for safe and smooth traffic
- (3) Recommended items to encourage passengers to behave to prevent problems caused by traffic
- (4) Knowledge about the structure of automobiles and driving

2) Practical Driving Lessons(training on the training roads and the public roads)

(1) On the training roads

① Basic capabilities

Whether the driver can perform basic driving operations is checked. The main issues to be checked are as follows: safely getting in/out and loading/unloading the wheelchair, safe and appropriate driving posture, safe and smooth operation of the operating devices, slow/fast operation of the steering, throttle, and brake at will, and proper handling and understanding of the names and functions of the devices.

② Selection of position (slow running speed)

This is to obtain the sensing capability of automobile size and running position at creep speed (the phenomenon that an automobile moves only by releasing the brake when the select bar is shifted to other positions than P and N with the engine on). The main issues to be checked are as follows: straight running, driving in a stable position, not running off the lane at corners and curves without swinging, and pulling over to

the kerb by running forward and backward.

③ Selection of speed

This is to obtain a selecting capability of suitable speed according to the driving site within the range from 0 to 40 km/h and a sensing capability of the running position. The main issues to be checked are as follows: driving in a stable position by selecting a suitable speed for straight and curved roads, corners, crossings, narrow roads, slopes, railroad crossings, signs, markers, and blind places, selection of a safe speed and direction considering obstacles, etc.

④ Confirmation and leading

This to obtain the ability to drive safely according to the traffic rules on standardized routes. The main issues to be checked are as follows:

- a. The driver can get in and out, and park the automobile.
- b. The driver can drive the automobile in the correct position with a speed suitable for the site.
- c. The driver can change direction safely and easily with accurate timing.
- d. The driver can pay careful attention to crossings and traffic and drive at a safe speed and in a safe manner.
- e. The driver can indicate the direction with accurate timing to make a right/left turn or change direction.
- f. The driver can select the speed and gear position if there is a slope and start the automobile without falling back after stopping.
- g. The driver can park the automobile safely in the parking position, etc. In addition, anti-skid training is conducted for driving on slippery roads, etc.

(2) Application training on the public road - part1

This is to learn basic driving according to the traffic rules paying careful attention to other traffic on public roads. The main issues to be checked are as follows:

- ① The driver can take left-hand traffic according to the road situation.
- ② The driver can select the driving position according to marks and indications.
- ③ The driver can appropriately address the situation by reading signs, marks, and indications.
- ④ The driver can pay careful attention to crossings and traffic and drive at a safe speed and in a safe manner.
- ⑤ The driver can drive the automobile in the correct position at a speed suitable for the site.
- ⑥ The driver can select the speed and the driving position for narrow roads, and drive safely.
- ⑦ The driver can recognize the movement of foot passenger, etc. and pay careful attention to their walking safely.
- ⑧ The driver can recognize the traffic situation and change the direction safely and easily.
- ⑨ The driver can park the automobile in an appropriate position in the correct manner, etc.

(3) Application training on the public road - part 2

This to obtain the ability to drive quickly and accurately in traffic, to recognize the relative position to other traffic and obstacles for maintaining a safe distance, and to take appropriate action by foreseeing danger-

ous situations. The main issues to be checked are as follows:

- ① The driver can slow down and stop at appropriate places and situations.
- ② The driver can start, accelerate, or brake the automobile at the right time according to the traffic.
- ③ The driver can select the appropriate position and speed for foot passengers, bicycles, and obstacles.
- ④ The driver can determine the relative speed and distance to the other vehicles, not bothering others.
- ⑤ The driver can foresee changes in the traffic situation and drive in good time.
- ⑥ The driver can guide others easily according to the traffic situation.
- ⑦ The driver can foresee a dangerous situation when driving.
- ⑧ The driver can set up the driving route voluntarily and drive independently.
- ⑨ The driver can understand the characteristics of high-speed driving and drive the automobile safely on highways.

Conclusion

Automobiles currently on the market have been developed and designed for persons without disabilities as the standard and improved for safety and comfort while driving. Descriptions on the safety of automobile bodies at collision are found in the data published in the automobile assessment, "Selecting safe automobiles," created by the Ministry of Land Infrastructure and Transport of Japan.

However, many automobiles used by persons with disabilities and assist devices retrofitted to automobiles have been developed for adaptability with automobiles and the convenience of users, rather than safety and comfort while driving, and no information on safety is currently available. It is hoped that automobile manufacturers and specialized manufacturers of assist devices for driving develop easy-to-use automobiles, etc. for persons with disabilities without sacrificing safety and comfort by considering the characteristics of persons with disabilities at the development phase.

In many cases, a person who is going to purchase an automobile, whether persons without disabilities or with a disability, goes to an automobile dealer shop, sees actual automobiles and catalogs, checks the performance and accessories, and decides whether to buy or not. However, most catalogs, etc. do not include the descriptions required for persons with disabilities to select an automobile. Recently, some automobile manufacturers indicate the height of the driving seat surface from the ground and present useful information for persons who need to get in an automobile from a wheelchair. However, because of the lack of other information, because no manufacturer's catalog indicates steering force, stepping force of the brakes as basic operations, the height of door step, the distance from the driver's door to the right edge of the driving seat for ease of getting in and out, etc., it is inconvenient and difficult to determine suitable automobiles.

It is expected that such information for persons with disabilities to select their automobiles will be stated in catalogs, etc.

In addition, to improve the safety and comfort of persons with disabilities in the future, it is necessary to deploy experts, who can guide and advise on the adaptability of automobiles and assist devices for driving, that per-

sons with disabilities can consult anytime.

References

- 1 Naoichi Tsuyama, Rehabilitation of Cervical Cord Injury, pp248-257, KYODO ISHO SHUPPAN CO., LTD., 1998
- 2 National Rehabilitation Center for Persons with Disabilities: Automobile Driving Lesson Guide Handbook for People with Disabilities, pp34-56 pp274-286, Chuohoki Publishers, 1990