Intervention Research for Quality of Life Improvement through the use of Personal Mobility Mode in an Aging Society

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Abstract: It seems that transport mobility is closely linked to person's well-being, especially to the elderly people. Preparation of certain transport devices to compensate for the decline in mobility of the elderly is important in order that they may move and lead an independent life in accordance with their desires. Such mobility devices as the electric carts suggest great utility for transport; however, the electric cart has yet to gain popularity in the open market. Thus, it is necessary not only to discuss expanding its usage but also to clarify its effects on improving the quality of life of the elderly in advance. The change in the quality of life from the viewpoint of health-welfare with and without the use of personal mobility mode (we describe it as PM from now on) in the daily life of the elderly is investigated using various types of evaluation measurements.

Keywords: Personal mobility, Quality of Life, SF-36, Life Space Assessment, International Classification of Functioning, Aging Society

1. INTRODUCTION

For the elderly whose physical functions have declined, in order to be able to move according to their will and to achieve a degree of independence, preparation of a certain transportation device which may compensate for this decline is important. Transportation devices include what is called PM, which includes such devices as the wheelchair and the electric cart. However, their use has not yet been widely accepted in Japan.

Clarification of the reasons for this and examination of new practical uses for PM is thus necessary. When PM is used as a transportation device, the kind of change exerted on the quality of the user's life must be clarified. As such, the essential aim of this study is to clarify the effects on quality of life from the viewpoint of medical and welfare through the use of personal mobility like an electric scooter by elderly people such that they may continue with their participation in social activities despite their difficult in moving over a long distance or time.

It seems that transport mobility often closely affected to person's well-being, that is, his quality of life. However, this linkage between them has been less understood. Recently, some studies on how transport mobility contributes to enhance quality of life have been carried out. Spinney *et al.* (2009) souk to quantify the impacts of transport mobility and investigated them

on the quality of life (QOL). Its results show significant variations in transport mobility by life situation and subjective QOL indices, and also show significant relation between transport mobility and QOL. Stanley *et al.* (2011) confirmed that there is a significant linkage between increased mobility and improved personal well-being through the reduction of social exclusion risk and the development of social capital.

These researches analyze relations between transport mobility which is performed by general transport modes, such as cars and public transports, and person's subjective well-being. However, it is very difficult not only to define individual subjective well-being itself but also to measure it because the mobility itself is one of factors which constitute well-being.

Research on the quality of life through the maintenance of roads and the provision of public transport services on the improvement of QOL has been carried out by Eitoku *et al.* (2010), Mizokami *et al.* (2010) and Mizokami *et al.* (2012). The last one seems to be the first research that examined the effectiveness for improvement in QOL by the usage of PM such as electric carts. However, we have not found any research verifying effects on QOL by PM which synthesizes both health and welfare evaluation measurements. The purposes of this paper are to focus on PM as one of many transport mobility modes and to measure its impacts to well-being from the viewpoints of health and welfare especially.

In Kumamoto prefecture in 2010, a study entitled "Verification Research on Providing Chargers that use Solar Power and New Ways to use Electric Vehicles such as Scooters" was conducted as a project supported by the Ministry of Internal Affairs and Communications to study a new method to utilize personal mobility and to identify the impact on quality of life. The Japan Red Cross Society Kumamoto Health Management Center was the representative of this investigative research project in cooperation with Kumamoto prefecture, several medical and welfare institutions, Kumamoto University and HONDA Motor Co., Ltd as an industry-government- academic collaboration research project.

2. INTRODUCTION OF PERSONAL MOBILITY AND IETREVETION FEILDS

2.1 Personal mobility

Personal mobility is defined as a transportation device such as an electric assist bicycle or an EV motorbike which bridges the gap between walking and conventional transport modes. We focus here on the electric wheelchair.

There are two common configurations of electric wheelchairs: those which use joysticks and those which use handles for operation. Wheelchairs which are manufactured for elderly people have a user group on average in their 70s. In Japan, the volume of shipment is 22,957 sets (joystick: 5,826 sets; handle: 17,131 sets) in 2008, indicating there are more handle types than joystick types. The present shipment number of handle-type wheelchairs has decreased by about 40 percent from 29,121 units in 2000, as shown in Figure 1. One reason why the volume of shipment is decreasing is the requirement for authorization that care is necessary in order to rent a wheelchair, which was mandated by the Long-term Insurance Law. Those who do not receive care authorization are presumed to be independent thus cannot receive nursing-care-insurance for wheelchair rental but must cover the total amount individually.

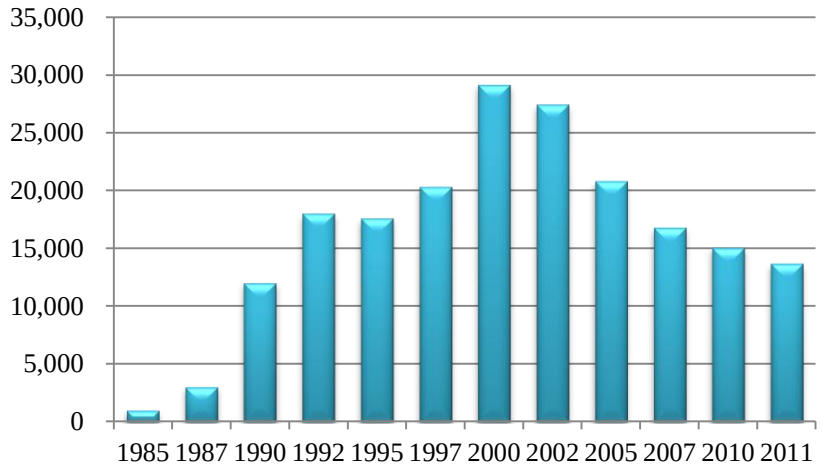


Figure 1. Shipment volume of handle form wheelchair

2.2 Specification of MONPAL

The personal mobility used for this intervention research is an electric wheelchair called MONPAL which has been made by HONDA since 2006. MONPAL is designed for senior citizens with physical disabilities, to enable them to move freely with ease. It is classified by the Traffic Rules of Japan as an electric wheelchair for physically challenged people. Key standards stipulated in the Japanese Road Traffic Act are that 1) dimensions must be limited to no more than 120cm×70cm×109cm; 2) it must possess an electric motor; and 3) driving speed must be limited to 6km/h. MONPAL's specifications are shown in Figure 2. Operators of MONPAL are classed as pedestrians, so they do not need a driver's license. However, there are legal restrictions for approved sizes and speeds.

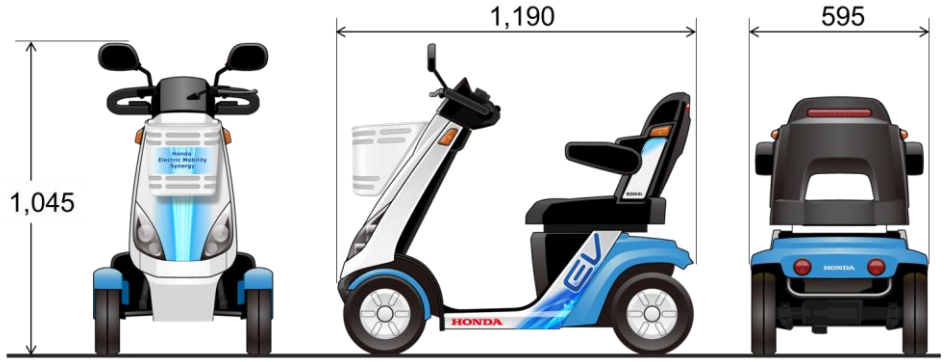


Figure 2. Characteristics of MONPAL

We equipped our test MONPAL not only with a data logger which records GPS tracking and operation data but also with a communication device which transmits these data at intervals for a set period of time. The latest MONPAL has also been equipped with a three-dimensional accelerometer and a driving camera which enables visualization of the driving environment to recognize actual points on runway where the revel of acceleration varies suddenly. MONPAL Tracker, as we named our device, can monitor these data

simultaneously, as shown in Figure 3.

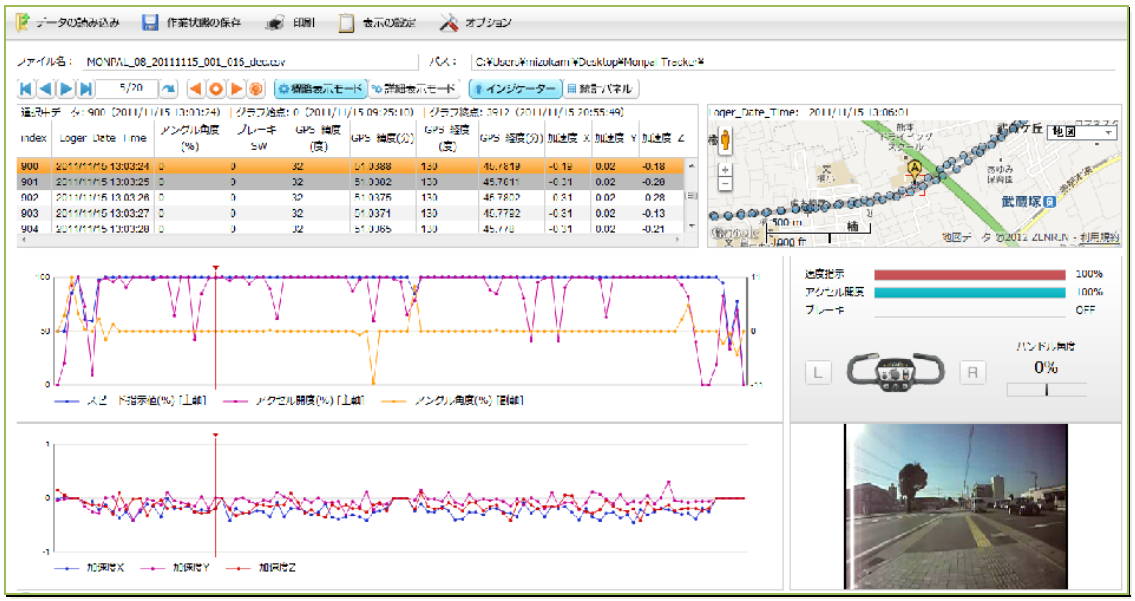


Figure 3. Monitor screen of MONPAL Tracker

3. INTERVENTION FIELDS AND QOL EVALUATION METHODS

3.1 Intervention Fields and Subjects

Three fields were selected for the scenarios of social interventions in 2010.

Field A: Elderly shared-use urban-life model scenario
Field A is collective housing for elderly people in the center of Kumamoto city. Residents depend for everyday movement on foot or taxi. We secured three residents as subjects to verify the possibility of shared use to visit adjacent retailers, medical clinics, and so on.

Field B: Healthy person life-base model scenario
Field B consists of health and cultural facilities existing in a suburb area of Kumamoto city. There, many elderly people go for exercise and cultural events. Although they live in close enough proximity to go on foot, most use cars or motorbikes. We lent out PM to five subjects and had them use the PM freely so that we could verify aspects of individual possession type use.

Field C: Nursing home shared-use model scenario
Field C is a nursing home in the suburbs of Kumamoto city. Those who reside there are inferior in walking ability. There are few opportunities for them to move on foot. Wet decided to verify aspects of private ownership-use by one tenant and shared-use by three daycare services.

3.2 QOL Evaluation Methods

In order to evaluate the degree of improvement in QOL, PMs were lent out for a period to subjects who had never used them; various QOL index values were compared from before and after MONPAL use.

a) Medical Outcomes Study 36-Item Short-Form (SF-36™)

The SF-36 is a multi-purpose, short-form health survey with only 36 questions. It yields an 8-scale profile of functional health and well-being scores as well as psychometrically-based physical and mental health summary measures and a preference-based health utility index as shown in Table 3. It is a generic measure. Accordingly, the SF-36 has proven useful in surveys of general and specific populations, comparing the relative burden of diseases, and in differentiating the health benefits produced by a wide range of different treatments.

Table 3 Summary of Information about SF-36 Scales and Physical and Mental Component

Scales	Definition (% observed)	
	Lowest Possible Score (Floor)	Highest Possible Score (Ceiling)
Physical Functioning (PF)	Very limited in performing all physical activities, including bathing or dressing (0.8%)	Performs all types of physical activities including the most vigorous without limitations due to health (38.8%)
Role-Physical (RP)	Problems with work or other daily activities as a result of physical health (10.3%)	No problems with work or other daily activities (70.9%)
Bodily Pain (BP)	Very severe and extremely limiting pain (0.6%)	No pain or limitations due to pain (31.9%)
General Health (GH)	Evaluates personal health as poor and believes it is likely to get worse (0.0%)	Evaluates personal health as excellent (7.4%)
Vitality (VT)	Feels tired and worn out all of the time (0.5%)	Feels full of pep and energy all of the time (1.5%)
Social Functioning (SF)	Extreme and frequent interference with normal social activities due to physical and emotional problems (0.6%)	Performs normal social activities without interference due to physical or emotional problems (52.3%)
Role-Emotional (RE)	Problems with work or other daily activities as a result of emotional problems (9.6%)	No problems with work or other daily activities (71.0%)
Mental Health (MH)	Feelings of nervousness and depression all of the time (0.0%)	Feels peaceful, happy, and calm all of the time (0.2%)

b) Life-space Assessment (LSA)

Daily physical activity was evaluated using life-space assessment (LSA), a relatively new instrument to measure mobility developed at the University of Alabama at Birmingham (Baker *et al.* 2003). LSA can assess movement ability which takes into account life-space level, degree of independence and frequency of attainment.

Life-space level is defined as the distance from the origin point of life-space, which is bedroom, and classified into 6 levels: those composed of Life-space 0, the bedroom; life-space 1, the home; life-space 2, the immediate outside; life-space 3, the neighborhood; life-space 4, the town; and life-space 5, unlimited. LSA score is calculated by the sum of (the life-space level) × (degree of independence) × (frequency of attainment) for all

life-activity from 1 to 5. Its minimum score is 0 and maximum is 120.

c) International Classification of Functioning, Disability and Health (ICF)
The International Classification of Functioning, Disability and Health, known more commonly as ICF, is a classification of health and health-related domains. These domains are classified from physical, individual and societal perspectives by means not only of a list of body functions and structure but also of a list of activity and participation.

ICF suggests application-specific research tools for measuring QOL for all persons regardless whether they have an illness or disability, so we determined that these tools are suitable for use as a QOL evaluation index for the subjects of this research. MONPAL is used as a means of transportation, so we deemed it to be especially suitable for evaluation using ICF composition elements of activity and participation. Details of actual classification items which we created, including several original questions, are explained below.

3.3 Date collection

Table 2 shows the attributes of 26 who agreed to be subjects initially. Half of these were eliminated from the intervention test, leaving 13 subjects with ID numbers from 1 to 13.

Table 2. Attributes of Subjects

CODE	id	ICF id	use frequency	sex	consent by family	Pre-medical exam	Pre-TUG grip	Post-medical exam	Post-TUG grip
A-1	1	L		M	△	○	○	○	○
A-2	2	K		M	○	○	○	○	○
A-3	3	J	◎	F	△	○	○	○	○
B-3				F					
B-4				F					
B-5	4	B	○	M	○	○	○	○	○
B-6	5	A	◎	M	○	○	○	○	○
B-7	6		×	M	○	○	×	×	×
B-8	7	C	◎	M	○	○	×	○	△
B-9				F					
B-10				F					
B-11	8	D	○	M	○	○	○	○	○
B-12				F					
B-13				M					
B-14				M					
B-15				F					
B-16				F					
B-17				M					
B-18	9	E	△	F	○	○	×	○	○
B-19				M					
C-1	10	I	◎	M	○	○	○	○	○
C-2	11	H	○	F	○	○	○	○	○
C-3	12	G		F	○	○	○	○	○
C-4	13	F	×	F	○	○	○	×	×

Note:
1) ◎, ○, △ and × in use frequency show frequently, sometimes, rarely and not at all, respectively.
2) ○, △ and × in consent by family and so on show completely, almost and not at all, respectively.

The intervention survey of these three fields was conducted according to the schedule shown in Figure 3. Before the actual intervention, a pre-questionnaire on preferences for and impressions of the MONPAL was conducted to subjects in the trial run. Results are shown in Table 3. Subjects were unfamiliar with MONPAL comprised over 70% of the total, meaning name recognition of MONPAL as an electric cart was unexpectedly low. Many subjects felt it was easy to operate and had a good impression after the trial. On the other hand, half of all subjects respond that it was difficult for them to drive in safety and at ease. This indicates the existence of certain psychological barriers against acceptance of MONPAL.

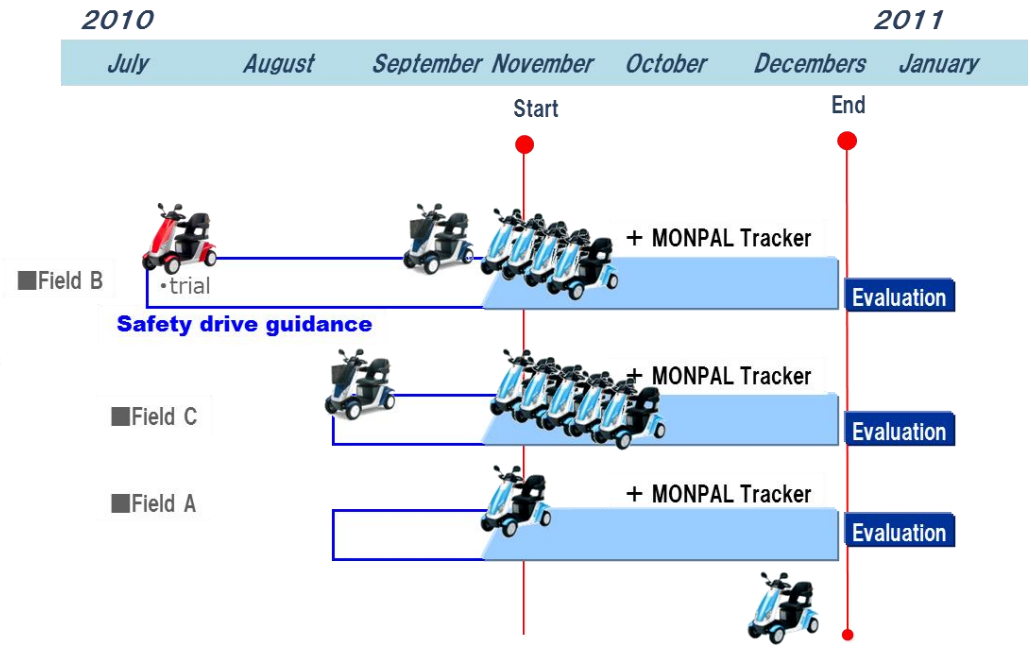


Figure 3. Schedule of interventions

Table 3. Results of pre-questionnaire

question	answer	comments
1. Sex	male [3], female [4]	
2. Age	fifties [1], sixties [1], seventies [2], eighties [3]	
3. Degree of care	care-1 [3], care-2 [3], care-3 [1]	
4. Driver"s license	with [4], without [3] (2 return because of age)	
5. Are you familiar with MONPAL?	no [5]	
	yes [2] (their friends have been using)	
6. What do you think about MONPAL after trial run?	good [6]	/better than car /speed is appropriate /stable and easy to drive with one hand
	Not good [1]	/afraid of driving and accidents
7. What do you think about its operation?	easy [6]	/easy to drive regardless of paralysis in left half side of the body /easy if once practice
	difficult [1]	/hard to operate accelerator levers
8. Can you drive with ease?	yes [4]	/easy if once practice a little
	no [3]	/worry about driving without attendant
9. What do you think about	expensive [3]	/appropriate if price is the same as a scooter

the price?	reasonable [1] unknown [3]	
10. Do you plan to continue use hereafter?	yes [4]	/for shopping [2], go to the hospital [3], friends [1] /drive within 2km distance /go to go parlor by it in place of car
	no [3]	/taxi is much easier to take /prevent decline of muscle
11. What is your impression?	/need 10km/h in maximum speed /rental system /go outside and take pictures /want to drive by myself /need much wider basket	

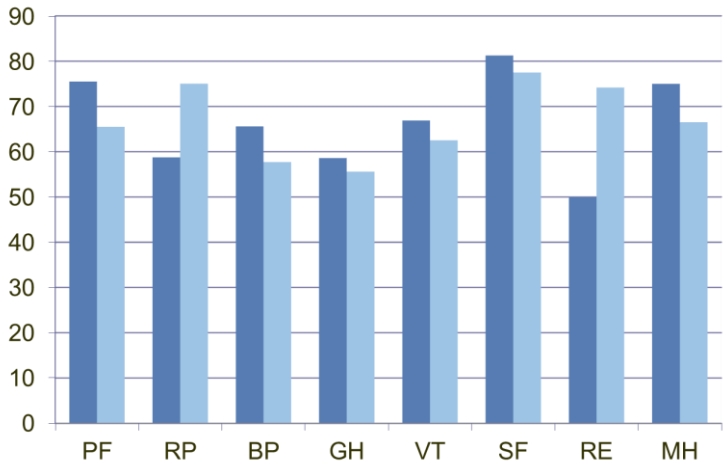
The SF-36 and LSA pre-questionnaires were conducted to all 26 subjects before the social intervention by the face-to-face interview method as well as some medical examinations and TUG grip test. We expect that all 26 subjects will participate in the social intervention. However, half of them did not participate in the intervention test from the beginning or escaped from it on the way, so post-questionnaires were conducted to13 subjects who have id number from1 to 13 in Table 2.

4. RESULTS OF QOL EVALUATION

4.1 Changes in SF-36™ NBS

The average of scores in 8-scale profiles of SF-36, which is standardized to norm-based scoring (NBS), both of before and after intervention is shown in Figure 4. The number of samples is fairly small, so we cannot usual t-test to assess the difference in average of population. In such case, we can use Wilcoxon signed-rank test which is a non-parametric statistical hypothesis test when comparing two related samples to assess whether their population means rank differ. The average in NBS of SF-36 of only two items, Role Physical (RP) and Role Emotional (RE), improved from before the intervention with statistically sufficient differences. On the other hand, the average of other items declined slightly without statistically significant differences.

The SF-36 questionnaire before using MONPAL was conducted during a comparatively warm day early in October. However, we conducted the same questionnaire survey after using MONPAL during the mid-December cold. This is likely the main reason why the score of physical components likes PF, BP, GH as well as VT declines.



initial	Name of scale
PF	Physical functioning
RP	Role physical
BP	Bodily pain
GH	General health
VT	Vitality
SF	Social functioning
RE	Role emotional
MH	Mental health

Figure 4. Averages of NBS in 8-scale profile of SF-36

4.2 Changes in LSA Score

Table 4 shows differences of LSA scores of individual subjects before and after using MONPAL as well as his/her degree of use frequency. LSA scores improved on four subjects, while it declined on four subjects. The tendency is clear that more frequent use of MONPAL leads to improvement in LSA scores and a wider activity sphere.

Table 4. Relation between LSA Score and use frequency

field / subject		Before	After	difference	use frequency
A	1	120.0	102.0	-18/0	△
	2	84.0	24.0	-60.0	△
	3	49.5	63.0	13.5	◎
B	4	102.0	120.0	18.0	○
	5	66.0	84.0	18.0	◎
	6	120.0	-	-	×
	7	84.0	84.0	0.0	◎
	8	120.0	63.0	-57.0	○
	9	120.0	63.0	-57.0	△
C	10	22.5	54.0	21.5	◎
	11	120.0	120.0	0.0	○
	12	18.0	-	-	×
	13	19.5	-	-	×

Note: ◎, ○, △ and × in use frequency show frequently, sometimes, rarely and not at all, respectively.

We divided all subjects into either an improved group or a static group based on their LSA score and compared the differences of the average in 8-scale profile scores of SF-36 for both groups. Table 5 shows the results. In the group which LSA score improved, the score of PF, BP and SF also declined; however, the score of RP, GH, VT and RE improved. On the other hand, in the group whose LSA score were static or worsened, improvement in the score of only RP and RE is recognized.

Table 5. Relation between LSA and SF-36

LSA \ SF-36		PF	RP	BP	GH	VT	SF	RE	MH
Improved Group	before	83.8	79.7	71	50.8	75.0	90.6	75.0	76.3
	after	60.0	93.8	61.5	55.8	76.6	87.5	89.6	76.3
	difference	-23.8	14.1	-9.5	5.0	1.6	-3.1	14.4	0.0
Static Group	before	75.0	46.9	62.5	66.0	57.8	68.8	35.4	73.8
	after	70.0	51.6	51.3	47.2	40.6	56.3	52.1	48.8
	difference	-5.0	4.7	-11.2	-18.7	-17.2	-12.5	16.7	-25.0

We can summarize the characteristics of each QOL measurement method from the above-mentioned considerations as follows:
1) It seems that the QOL by PM use cannot be fully assessed by only using SF-36, a comprehensive QOL evaluation method.
2) Conversely, PM use improves the LSA score, which shows the subject's life-space activity. There is a slight correlation between the score of LSA and SF-36.
3) This LSA score appears to explain the comprehensive evaluation score by SF-36 to some extent.
3) LSA certainly shows the degree of activity life space, but it can explain neither purposes nor methods by which each subject widens activity life space. Therefore, clarification of the types of functions, including activities and participation, which increase the LSA score is required.

5. QOL EVALUATION BY ICF

5.1 ICF questions

Levels of activity - i.e., individual performance of problems or actions - and participation - i.e., engagement in life and life situations - which seem to be factors of ICF should be evaluated because the use ICF suggests application-specific research tools for measuring QOL for all persons through various types of functioning regardless of whether or not they have an illness or disability.

Unlike the scoring for a comprehensive evaluation index like SF-36, the contents of ICF allow for changes that affect part of an individual’s lifestyle. MONPAL is used as a means of transportation, so we deemed it to be especially suitable for evaluation of ICF composition elements of activity and participation.

We proposed an interview guide with nine classification items based on “The use of ICF,” which was created by the Ministry of Health, Labor and Welfare (2007). From these nine classification items of functioning, we create 13 questions which are composed of (1) 2 questions on “learning and applying knowledge”, (2) 2 questions on “general tasks and demands”, (3) 1 question on “communication”, (4) 1 question on “mobility”, (5) 1 question on “self-care”, (6) 1 question on “domestic life “, (7) 2 questions on “interpersonal interactions and relationships”, (8) 1 question on “major life and areas”, and (9) 2 questions on “community, social and civic life”. Table 6 shows the narrative contents of these 13 questions.

Table 6. The narrative contents of these 13 questions

classification	No.	Questions	Yes (%)
(1) Learning and applying knowledge	1	Did you practice measurement of driving MONPAL actively?	83.3
	2	Did you undertake very enthusiastically tasks, or come to carry out tasks after using MONPAL?	41.7
(2) General tasks and demands	3	Did you come to more easily carry out tasks such as daily routine after using MONPAL?	33.3
	4	Did you carry out new daily routine after using MONPAL?	50.0

(3) Communication	5	Did you increase opportunities of communication with family, friends, neighbors, etc. after using MONPAL?	83.3
(4) Mobility	6	Did you increase the frequency of going out or moving your body after using MONPAL? Did you increase going to places you had never been after using MONPAL?	50.0
(5) Self-care	7	Did you come to more easily venture out to the neighborhood such as hospital after using MONPAL?	50.0
(6) Domestic life	8	Where you charged with household errands after using MONPAL?	25.0
(7) Interpersonal interaction & relationship	9	Did you make new associations after using MONPAL?	41.7
	10	Did your family bonds deepen after using MONPAL?	25.0
(8) Major life area	11	Did you get work anything after using MONPAL?	10.0
(9) Community, social & civic life	12	Did you play a more active social role after using MONPAL?	16.7
	13	Did you increase enjoyment of recreation and leisure after using MONPAL?	16.7

5.2 QOL Evaluation by ICF

Using the interview guide, we held individual semi-structured interviews with 12 subjects using the three-answer selection method - i.e., YES/ NO/ Neither - for 13 questions to perform a subjective evaluation. The ICF questionnaire was carried out by the interview method to 12 subjects who are shown from A to L in ICF-id column in Table 2 after the social intervention. Two points were assigned to a "YES" response, and zero points were assigned to the "Neither" and "NO" responses. Using the sum of points for 13 questions, we can analyze the performance of activity and participation quantitatively. ICF point totals for individual questions by subject are shown in Table 7.

Table 7. Score of ICF activity and participation dimensions

Class.	(1)		(2)		(3)	(4)	(5)	(6)	(7)		(8)	(9)		total
No. / ICF id	1	2	3	4	5	6	7	8	9	10	11	12	13	
A	2	0	2	0	2	0	2	0	2	0	0	0	0	10
B	2	0	0	2	2	2	2	2	2	2	0	0	0	16
C	0	0	0	0	0	0	2	0	0	0	0	0	0	2
D	2	2	2	2	2	2	2	2	0	0	0	0	0	16
E	2	2	2	2	2	2	0	0	2	2	0	2	2	20
F	2	0	0	0	0	0	0	0	0	0	0	0	0	2
G	0	0	0	0	2	0	0	0	0	0	0	0	0	2
H	2	2	0	0	2	2	2	0	2	0	0	0	0	12
I	2	2	2	2	2	2	2	2	2	0	2	2	2	24
J	2	0	0	2	2	0	0	0	0	0	0	0	0	6
K	2	2	0	2	2	2	0	0	0	2	0	0	0	12
L	2	0	0	0	2	0	0	0	0	0	0	0	0	4
total	20	10	8	12	20	12	12	6	10	6	2	4	4	

We note below some interesting results on the subjective QOL evaluation by ICF and the relation between the ICF score and SF-36 score:

1) QOL in functioning of “activities” such as (1), (3), (4) and (5) improved considerably, but regrettably, QOL improvement in “participations,” which involve high order functioning such as (8) major life area and (9) community, social and civic life, was not achieved.
2) A major improvement in QOL for subjects I and E can be seen. On the other hand, there was little improvement in QOL for subjects C, F, G and L. Almost all of them state, “I drive MONPAL inside of the special nursing home and care staff”.
3) The average of the total points by the four subjects who state, "I cannot ride freely by myself" is 5.0 points. By comparison, the average of eight subjects who state, "I can freely ride by myself" is 13.3 points. T-test finds a statistically significant difference in average by 5% level. Therefore, we can expect a greater improvement in QOL if the individual is able to operate MONPAL by himself and if the environment allows him to move around freely.
4) There is no correlation between the ICF score and FS-36 score in the way as there was between LSA score and SF-36 score.

6. CONCLUSION

To conclude:

(1) Improvement in QOL solely in terms of ICF activity and participation does not by itself improve comprehensive QOL, which is an important issue that should be pursued in the future through theoretical and empirical study. On the other hand, it does improve the level of mobility for subjects.
(2) We should investigate the value that MONPAL increases the number of functioning such that we can move anywhere and we achieve any purpose from the viewpoint of the Quality of Mobility.
(3) We have been holding an interview over and over again with subjects in these three social intervention fields for performance which MONPAL itself and surroundings should achieve. There seems to be three main barriers which must be overcome until to enable the elderly to use MONPAL as a transportation device in their daily life.
1) Psychological barrier: people do not want to look so weak that they can no longer walk by themselves.
2) Environmental barrier: infrastructure and environment such as road surface and running space in facilities are not suitable for MONPAL operation.
3) Operational barrier: performance and standard of MONPAL itself is not sufficiently user-friendly.
(4) At the same time, we find sufficient possibility that MONPAL can become a safe and secure means of transportation for maintaining the QOL of the elderly.

Within this coming 10 years, a dramatic change in population structure and illness type looms in Japan. The next stage of Japanese national health promotion policy, which starts from 2013, will change its emphasis from improvement of ‘individual health performance’ to the improvement of quality of ’individual behavioral transfiguration’ and ‘realization of a good social environment’. Regional infrastructure is indispensable to elderly people’s healthcare. Creation of a mechanism and environment which does not isolate elderly people indoors and which rebuilds a local social community is necessary. Securing the elderly’s QOL will likely be an urgent need in order to maintain the social security system. Thus, the development of certain transportation device by which elderly people can perform some activities and participate in social activities is of great importance.

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