Factors Associated with Decision to Participate in Physical Activity by People with Spinal Cord Injury: An Analysis using Decision Tree

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Abstract

Background/Objectives: The purpose of this study is to analyze the effects of interactions between factors that determine whether or not to participate in physical activities by people with spinal cord injury. Methods/Statistical Analysis: Subjects of this analysis include people, who are over 19 years of age, with spinal cord injury (260 males and 56 female). A decision tree analysis was used for this research. Findings: The study results are as follow: Most important factors that determine one's participation in physical activities despite previous spinal cord injury were shown to be in the sequence of personal care providers and personal assistants (e340), disability grade, design, construction and buildings product and technology of building for private use (e155), carrying out daily routine (d230), protective function of the skin (d810); the rate of participation in physical activity is the highest when classified as significant impacts in personal care providers and personal assistants (e340), and affected and no affected and mild in disability grade. Application/Improvements: In conclusion, an analysis of the interactions between factors is effective in understanding whether to participate in physical activities or not.

1. Introduction

Physical Activities (PA) have been known to be associated with reduction and prevention in the risk of chronic diseases, such as Cardiovascular Disease (CVD), Diabetes Mellitus (DM), cancer, osteoporosis etc⁰. PA has been actively recommended for people with Spinal Cord Injury (SCI) that lack involvement in PA². According to recent studies, the PA participation rate of people with SCI is very low³⁴. Since reasons for the low participation rate cannot be explained by any one factor, there is a need to analyze the interaction between factors that contribute to one's decision to participate in PA and to understand the factors structurally.

PA has been reported to improve physical fitness, functional independence, and psychological well-being, and to reduce the risk factors of chronic diseases and secondary health problems⁶⁸. Especially, PA have reduced risks of CVD, DM, and obesity, which are the most general causes of death for people with SCI⁹¹⁰. Furthermore, the depressive symptom and life satisfaction has been changed positively, which improved subjective well-being through social participation⁸¹¹. Most authors have previously reported that PA have an effect in preventing chronic disease, enhancing physical strength, improving functional independence, and reducing depressions for people with SCI⁷¹².

Moreover, 50% of people with SCI have not participated in PA⁴, and the PA level remained to be at only 40% of the general population⁵. The rate of participation in PA in all types of disabilities is 14.1%; and the rate of spinal disability amongst the disabled is only 10.7%⁵. It is due to physical inactivity of people SCI and constraints of physical environments, in combination,
that result in reduction of body function\cite{10}. Many studies have investigated the barriers against PA of people with SCI. These studies presented the following to important: accessibility to buildings or facilities, emotional and psychological barriers\cite{13,14}, intrapersonal constraints, such as lack of motivation or lack of energy\cite{15}. In addition, previous studies presented resources (e.g., cost of an exercise program, not knowing where to exercise), perceptions and attitudes toward persons who are not disabled, mental health problems, and etc\cite{13–16}. Pressure ulcer has been reported as a major cause for re-hospitalization in people with SCI\cite{16}. The first step to facilitate participation in PA for people with SCI is to correctly the barriers that inhibit participation\cite{15}. Previously, the facilitators have been reported as availability of accessible facilities, personal assistants, personal motivation, fear of health complication, support from family, friends and society, easily accessible stores and buildings in the neighborhood, etc\cite{13,17}.

These studies have contributed to reminding people that current social and physical environments are very disadvantageous to people with SCI. However, this alone is lacking in the comprehension of PA participation, consequently limiting in the enhancement of PA. Now, we should see beyond the level of exploring certain variable and analyze how the factors affecting PA participation interact with each other.

International classification of functioning, disability and health (ICF) explains the functions of disabled people through a standard classification system in a common structure; components of ICF (body functions and structure, activities and participation, environment factors, personal factors) are effective measurement tools in analyzing social constraints and identifying characteristics of individual or groups. In addition, ICF is so vast that the field utilization is low at this time; thus, it was recommended to prepare and use the essential criteria for collecting information about a particular disease\cite{18}. Typically, there is an ICF Checklist\cite{19} and ICF core set for people with SIC\cite{20}. Especially, there are 3 types of ICF core set, such as generic, brief, and comprehensive ICF core set\cite{21}; this study used the Brief ICF core sets.

Therefore, the purpose of the study is to analyze how the evaluation items of the Brief ICF core set for SCI in long-term care are combined to interact with each other in PA participation of people with SCI.

## 2. Methods

### 2.1 Subjects

Subjects are people with SCI over the age of 19 years; the community of people with SCI participated through the Rehabilitation Support Center of the Korea Spinal Cord Injury Association. The Rehabilitation Support Center supports people with SCI to quickly return to normal daily activities by providing them with counseling and rehabilitation services. The convenience sampling method was used for sampling. The survey was performed using a self-administrated survey method, only when participants agreed after explaining the purpose of the study. A total of 361 persons’ data (N = 260 male, N = 56 female) were analyzed. The characteristics of the subjects are shown in Table 1.

### 2.2 Target Variables

The target variables of the study are whether or not to participate in physical activities. “The stage of exercise behavior change” was used for whether or not to participate in PA\cite{22,23}. When answering “yes” to “I have been for MORE than 6 months. And I have been for LESS than moths”, the person was classified as a PA participant; when answering “No”, the person was classified as a PA non-participant.

### 2.3 Explanatory Variables

The “Brief ICF Core Set for SCI in long-term care” was used as explanatory variables in the study. This contains essential information for efficiently describing the individual experiences about the functions and disorders

| Item    | n   | %  |
|---------|-----|----|
| Gender  |     |    |
| Male    | 260 | 82.3 |
| female  | 56  | 17.7 |
| Age(years) |     |    |
| ≤29     | 44  | 13.9 |
| 30-39   | 93  | 29.4 |
| 40-49   | 97  | 30.7 |
| 50-59   | 65  | 20.6 |
| 60≥     | 17  | 5.4 |
| lesion  |     |    |
| cervical | 111 | 35.1 |
| thoracic| 177 | 56.0 |
| lumbar  | 28  | 8.9 |
of people with SCI\textsuperscript{21}. The questions are composed of body functions (9 items), activities and participation (13 items), environmental factors (9 items), and personal factors (5 items), using the ICF two-level classification system. The study excluded body structures that require specialized anatomical knowledge because the study collects data via a self-administrated survey method.

Response options for the body function and activities and participation were classified into four types. The 4 options for body function were not damaged at all, little damaged, slightly damaged, much damaged. The 4 options for activities and participation were not uncomfortable at all, little uncomfortable, slightly uncomfortable, very uncomfortable. The environmental factors were classified into the following 5 categories: Not affected, a little bit affected, affected, generally affected, much affected. The personal factors used 5 categories (final education, household income, disability grade, chronic diseases, and number of family members) for the analysis. The response options for the final education were middle school graduation, high school graduation, and college graduation or more; the options for household income were less than 2 million won, less than 4 million won, and 4 million won or more. The options for disability level were mild and severe, the options for chronic diseases were yes or no. The options for the number of family members were less than 2 persons, less than 4 persons, and 5 persons or more. The detailed descriptions and response options for the explanatory variables used in the study were configured based on prior studies\textsuperscript{24,25}, and the specific explanatory variables are shown in Table 2.

2.4 Data Analysis

In order to analyze how the two explanatory variables or more do influence whether people with SCI participate or not in PA, the decision tree analysis was utilized. The decision tree analysis is a method of classifying the object group of interests into a couple of subgroups by expressing them in a tree structure or by performing predictions\textsuperscript{26}. This analysis method investigates the interaction effects that several explanatory variables have on target variables in combination. The response options for the remaining explanatory variables except the personal factors were grouped and re-coded for the analysis. The options not damaged at all and little damaged were merged into not damaged; slightly damaged and much damaged were merged into damaged for the category of body function. The options not uncomfortable at all and little uncomfortable were merged into not uncomfortable; slightly uncomfortable and very uncomfortable were merged into uncomfortable when re-coding the category of activities and participation. The options of a little bit affected, affected, and generally affected were merged into affected when re-coding the category of environmental factors; the remaining options of not affected and much affected were used as coded initially.

The software of SAS Enterprise Miner 13.1 (SAS institute Inc., Cary, NC, USA) was utilized for statistical analysis. In the multi-way split, CHAID (chi-squared automatic interaction detector) were used to examine the interactions between multiple significant variables. In the split criterion, Gini index was utilized; in the stopping rule, the maximum tree depth was set as six. Data were segmented into training data (70%) and validation data (30%) to review the validity of a decision tree analysis. Statistical significance was set at p<0.1.

3. Result

The classifications of multi-tree structure using CHAID algorithm is shown in Figure 1; the tree structure made up of a total of six terminal nodes was formed. The participation rate of training data and the participation rate of validation data in the top of the root node (Node ID 1) were 68.78% and 69.47%, respectively.

As shown in Figure 1, the most important factors determining whether people with SCI participate in PA or not were shown to be in the sequence of personal care providers and personal assistants (e340), disability grade, design, construction and building product and technology of building for private use (e155), carrying out daily routine (d230), and protective function of the skin (b810).

The interaction effects of the explanatory variables affecting whether or not to participate in PA are as follows: The PA participation rate was increased to 100%, the largest (node ID 5), when e340 was affected and not affected and disability grade was mild. The PA participation rate was increased to 89.19% (node ID 8) when disability grade was severe and e155 was not affected and much affected and d230 was uncomfortable while comprising the above conditions. Lastly, the PA participation rate was increased to 83.33% (node ID 10) when d230 was not uncomfortable and b810 was not damaged.

The gain chart is presented in Table 3. The node with the highest rate in PA participation of people with SCI is located on the top of Table 3. Index (%) means the rate to
Table 2. The explanatory variables

| ICF code Title (two-level) | Body function         | Activities and participation | Environmental factors | Personal factors |
|---------------------------|-----------------------|-------------------------------|-----------------------|------------------|
| b130 Energy and drive functions | b710 Mobility of joint functions | d230 Carrying out daily routine | e110 Products or substances for personal consumption | Final education, Household income, Disability grade, Chronic disease, Number of family members |
| b152 Emotional functions | b730 Muscle power functions | d240 Handling stress and other psychological demands | e115 Products and technology for personal use in daily living |                          |
| b280 Sensation of pain | b735 Muscle tone functions | d410 Changing basic body positions | e120 Products and technology for personal indoor and outdoor mobility and transportation |                          |
| b525 Defecation functions | b810 Protective functions of the skin | d420 Transferring oneself | e150 Design, construction and building products and technology of buildings for public use |                          |
| b620 Urination functions |                       | d445 Hand and arm use          | e155 Design, construction and building products and technology of buildings for private use |                          |
|                         |                       | d450 Walking                  | e310 Immediate family |                          |
|                         |                       | d455 Moving around             | e340 Personal care providers and personal assistants |                          |
|                         |                       |                                | e355 Health professionals |                          |
|                         |                       |                                | e580 Health services, systems and policies |                          |

Table 3. Gain chart

| Node | Gain index | Cumulative index |
|------|------------|------------------|
|      | Node: %    | Index: (%)       | Node: %    | Index: (%)       |
| 5    | 3.17       | 145.39           | 3.17       | 145.39           |
| 8    | 16.74      | 129.67           | 19.91      | 132.17           |
| 10   | 2.71       | 121.15           | 22.62      | 130.85           |
| 7    | 50.23      | 99.55            | 72.85      | 109.27           |
| 2    | 24.43      | 78.08            | 97.29      | 101.44           |
| 11   | 2.71       | 48.46            | 100.00     | 100.00           |

The index (%) of Node ID 5 was 145.39%. This result implies that the condition of the node ID 5 showed a rate of PA participation to be 1.45 times higher of PA participation than the participation rate of the node ID 1 (68.78%), which was the case without entering any explanatory variable. The index (%) of Node ID 8 was 129.67 %. This result implies that the condition of node ID 8 showed a rate of PA participation to be 1.29 times higher than the participation rate of node ID 1 (68.78%), which was the case without entering any explanatory variable. The index (%) of Node ID 10 was 121.15%. This implies that the condition of node ID 10 showed a 1.21 times higher rate of PA participation than the participation rate of node ID 1 (68.78%), which was the case without entering any explanatory variable. The indexes (%) of other node IDs 7, 2, and 11 were shown as 99.55%, 78.08%, and 2.71%, respectively.

be more highly likely to be classified as PA participants when becoming consistent with the conditions of a specific node than when entering no explanatory variable (which means the participation rate of the node ID 1 on the top in Figure 1).
respectively, which were insignificantly increased or rather decreased in change rate compared to the participation rate of the node ID 1.

4. Discussion

It might be considered a cliche to deal with topics surrounding the participation of PA at this time. A common prerequisite for studies on the benefits of PA to date has been regular PA. However, it is difficult to meet such prerequisite due to several reasons. Therefore, the purpose of the study was to analyze how the evaluation items of the Brief ICF Core Set for SCI in long-term care are combined to interact with each other in the PA participation of people with SCI.

Our study results presented that the interactions of multiple variables are influencing whether people with SCI participate in PA or not. It was effective to grasp whether or not to participate in PA through the structural relationships between the variables. In addition, we identified the fact that the variables have mutual relatedness and interactions. While various factors that have been presented by prior studies seem to act alone, it is shown that they are interacting with each other based on the characteristics of the disability types. Based on our results, the variables related to physical functions of people with SCI interact with each other. Specifically, factors such as personal care providers and personal assistants, disability grade, products and technology for personal use in daily living, carrying out daily routine, and protective functions of the skin sequentially affected the decision on whether or not to participate in PA.

Examining the variable one by one in detail, personal care providers and personal assistants (e340) is about how much influence personal assistants, such as home assistants or activity assistants, may have on people with SCI. The rate of PA participation is shown to be higher with less influence from personal assistants. This suggests that influences personal assistants are important for people with SCI and loss of physical functions. Our result is consistent with the results from a prior study that emphasized the role of personal assistants as a facilitator.

Disability grade is to classify the severity of the individual disability by segmenting it into several stages. The participation rate was higher when the disability level was classified as mild. This is due to relative freedom from the barriers that surrounds them. Products and technology for personal use in daily living (e155) is about how much amenities are installed in the private space that influence the person’s daily life. This strongly suggests that limitations in physical functions caused by SCI influences daily activities and participation. As can be seen from the fact that the variable of building or facility accessibility is the major barrier, factors that can help overcome physical limitations have had important effects.

Carrying out daily routine (d230) is about the extent of discomfort in the overall daily life. There exist many limitations in the daily life of people with SCI in the current environment created by humans whereby carrying out daily routine has emerged as a variable that determine participation in PA. Protective functions of the skin (d810) are about the skin functions. The pressure ulcer is a complication that occurs most frequently to people with SCI. This is the major cause for the re-hospitalization. Since the results of our study show a higher PA participation rate, when classified as a category in which the skin function was not damaged, the results are closely related to prior studies.

Figure 1. Analyzing factors affecting whether or not to participate in PA using the decision tree analysis.
5. Conclusions

In conclusion, our study results present the fact that multiple factors, such as personal care providers and personal assistants (e340), disability grade, design, construction and building products and technology of buildings for private use (e155), carrying out daily routine (d230), and protective functions of the skin (b810) have important impacts on whether people with SCI participate in PA or not through mutual interactions. On the basis of the results of this study, it will be important to analyze the interactions of multiple factors than to analyze individual factors to determine PA participation.

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7. References

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