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Original Article

Is There a Causal Relationship between Body Imagery, Motor Imagery and Mental Health in Patients with Rheumatoid Arthritis.
— An Investigation Using Structural Equation Modeling —

Tatsuhiko Yamazaki, RPT, MS[1, 2] , Junichi Yamashita, RPT, PhD [3] , Sumiko Yamamoto, RPT, PhD [2]
1) Shizuoka Tohto Medical College (1949 Minami- Ema, Izunokuni - City,Shizuoka 410-2221,Japan)
2) Graduate School of International University of Health and Welfare
3) JA-Shizuoka Kosei Nakaizu Onsen Hospital

Abstract: [Purpose] This study aims to clarify the causal relationship between how mental health influences the body imagery and motor imagery of rheumatoid arthritis (RA) patients.[Participant(s) and Methods] The subjects were female RA patients hospitalized at a collaborative research facility. Basic attributes, mental health, physical function, body imagery, and motor imagery were measured, and causal relationships were statistically determined. [Results] Structural equation modeling was used to examine the causal relationships between mental health and body imagery and motor imagery. The model displayed a high degree of fit. [Conclusion] It was shown that the mental health changes that occur after the onset of RA affect body imagery and motor imagery. However, we found that mental health did not affect body imagery directly but indirectly through physical function. We believe that providing psychological support from the early stages of RA onset, preventing the decline of physical function, and training to improve motor skills with a focus on motor imagery are useful for RA patients.

Keywords: Mental health, Body imagery and motor imagery, Structural equation modeling

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I. INTRODUCTION

Rheumatoid arthritis (RA; abbreviations are listed at the end of this paper) is known to affect not only physical symptoms but also mental health, due to self-efficacy. Studies have reported a relationship between quality of life (QOL) and symptoms of anxiety and depression [1-3]. It has also been shown that the decline in mental health of RA patients caused by factors such as pain and deformity is related to the distortion of Body Imagery (BI) [4-5]. BI is a body schema that is integrated through proprioception and other means, as well as a comprehensive image of the body [6-7], and is the information that is projected onto Motor Imagery (MI). On the other hand, MI is a movement simulation that activates movement patterns and muscle activity before motor output. In MI, the more accurate the internal information, the higher the accuracy. Although it has been shown that the decline in QOL in RA patients is influenced by a decline in BI, previous studies have only examined the influence of RA symptoms on BI or the influence of mental health on BI [8-10]. RA symptoms and mental health decline are complex, and we believe that they need to be considered comprehensively.

Therefore, in this study, we aim to use Graphical Modeling (GM) and Structural Equation Modeling (SEM) to structurally analyze the relationship between RA-related factors and BI, MI, and mental health, and to clarify their causal relationships. Using such models, we sought to gain insight into the consideration of the sequence of therapeutic interventions by clarifying the interrelationships between BI, MI, and mental health, which have previously only been examined as individual factors.

II. PARTICIPANTS AND METHODS

1. PARTICIPANTS

The survey period was from April 2021 to January 2022. The subjects were 92 female RA patients aged 40 to 75 years who were hospitalized at a collaborating research facility during the survey period and gave their consent to participate in this study. In Japan, the prevalence of both RA and depression are higher in females than males [11-12]. We included female RA patients in order to clarify the correlation between BI, MI, and mental health.

2. METHODS

Information on the basic attributes of the subjects were collected, including age, years of disease, Hasegawa Dementia Scale-Revised (HDS-R), and RA disease activity. Disease Activity Score in 28 Joints-C-Reactive protein (DAS28CRP) was used to measure RA disease activity [13]. The DAS28CRP survey consists of the tender joint count and swelling joint count in 28 joints (bilateral shoulder joints, elbow joints, wrist joints, metacarpophalangeal joints, proximal interphalangeal joints, thumb interphalangeal joints, and knee joints), as well as test values for C-reactive protein and the patient's global assessment.

The Timed Up and Go test (TUG) was used to evaluate physical function. TUG is highly correlated with lower limb muscle strength and balance ability, and has been reported to be a reliable assessment of physical function [14-15]. The measurements were taken twice under maximum speed conditions in accordance with a previous report [16], and the minimum value was used as the representative value.

For the mental health assessment, we used the Japanese version of the Anxiety Sensitivity Index-Revised (JASI-R) [17], which determines the subject's degree of mental health stress from self-impression regarding appearance. The JASI-R consists of 13 items covering characteristics of self-evaluation and characteristics of motivation. Characteristics of self-evaluation refer to the extent to which one feels that appearance influences one's self-evaluation and daily experiences. Characteristics of motivation refer to the amount of effort one expends to improve and maintain physical attractiveness. For each question, participants were asked to respond using a five-point scale ranging from "not at all applicable" to "very applicable."

The Hand Laterality Judgement test (HLJT) is a mental rotation task in which a rotated image of a hand is presented and participants are asked to quickly judge whether the presented test image is the left or right hand, making it possible to evaluate physical accuracy [18]. The measurement method consisted of eight types of hand line images presented on a PC screen, which were rotated clockwise from 0° to 315° in 45° increments. A total of 16 types, including left and right hands, were randomly presented to participants, and they were asked to answer as quickly as possible which hand they were, and rate of correct answers and time required were measured.

The Movement Imagery Questionnaire-Revised Japanese Version (JMIQ-R) [19] was used to evaluate MI. The JMIQ-R is a questionnaire consisting of Kinesthetic Motor Imagery (KMI) and Visual Motor Imagery (VMI) items. Subjects were asked to measure KMI and VMI for four movements using their own limbs. Such tasks included lifting the right knee while standing on the left leg and moving the non-dominant hand from the side to the front. All tasks were not performed physically, but in the imagination. Subjects were asked to imagine the motor tasks described in the questionnaire and were asked to indicate the difficulty of imagining them using a 7-point scale ranging from "very difficult" to "very easy."

In addition, we measured the imaginary Timed Up and Go test-gap (iTUG-gap) to assess MI. iTUG-gap allows for objective evaluation of the accuracy of MI based on the difference between the image of the TUG act and the TUG results [20]. The measurement method was based on a previous study [21]. The subjects sat in a chair, with their eyes open and closed alternately at any time to start the measurement. They were instructed to imagine the TUG motor action and to stop the stopwatch measurement when they judged that they had sat down in their mind; that time was recorded as iTUG. Taking motor learning into account, the measurements were standardized by first performing iTUG and then TUG. The results were calculated in accordance with previous reports, in which the absolute value of the difference in time required between iTUG and TUG was used as the measurement value [22].

JUSE-Stat Works/V4.0 from JUSE was used for our analyses and the significance level was set at 5%.

After checking basic statistics, we conducted GM and SEM analyses. A causal model was obtained after confirming the relationship between observed variables using a directed independence graph. SEM obtained the relationship between factors using standard solutions.

This study was approved by the International University of Health and Welfare Research Ethics Committee (approval number: 20-lg-185-4) and the Nakaizu Onsen Hospital Ethics Review Committee (approval number: 2750).

III. RESULTS

Basic attributes and measurement results of the subjects are shown in Table 1. The subjects' average age was 59.5 ± 7.5 years and their HDS-R score was 29.3 ± 1.0, indicating that they were not affected by dementia.

The independence graph obtained from the obtained variables is shown in Figure 1. The cutoff criterion for partial correlation coefficients was set at 0.15 in absolute value, and covariance selection was performed using the backward elimination method. Residuals with an absolute value of 0.2 or greater were reconnected. Four cliques 1) mental health, 2) physical function, 3) BI, 4) MI were obtained from the derived independence graph. The goodness of fit of this independent model was GFI (Goodness of Fit Index) = 0.947 and AGFI (Adjusted Goodness of Fit Index) = 0.911. The relationships among the four cliques are shown as a directed independence graph (Figure 2) (model fit: GFI = 1.00, AGFI = 0.99, SRMR (standardized root mean square residual) = 0.005). The mental health of RA patients about 10 years after onset affected their physical function and MI. Furthermore, a structure in which physical function influences MI, and a tendency for physical function to influence MI via BI, was shown. Based on these results, the causal relationships of the measurement items with the four cliques as latent variables were shown in Figure 3 using SEM. The observed variables that were most involved in constructing the latent variables were the number of years of illness for mental health, TUG for physical function, HLJT (rate of correct answers) for BI, and iTUG-gap for MI. Furthermore, mental health did not directly affect BI, but indirectly through physical function. Mental health also showed a tendency to have an indirect effect on MI rather than a direct effect. The goodness of fit of this model was p = 0.03 by chi-square test, GFI = 0.90, AGFI = 0.85, and RMSEA（Root Mean Square Error of Approximation）= 0.046.

IV. DISCUSSION

We investigated the causal relationship between the mental health of RA patients and BI and MI, which has not been clarified until now.

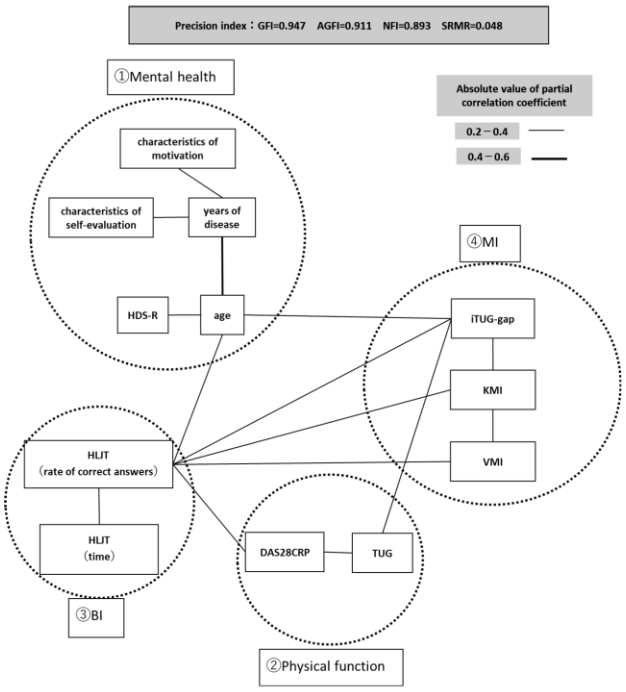
To ascertain the results from structural equation modeling, the relationships between factors were confirmed using graphical modeling. A directed independence graph taking into account the passage of time revealed that mental health precedes and influences physical function, BI, and MI. In RA patients, pain and deformity associated with the onset of the disease progresses rapidly within two years. Hence it is important to take into consideration their mental health during this period, and medications can be adjusted based on symptoms. In addition to pain, this is a time when fatigue occurs due to the side effects of anti-rheumatic drugs and biological agents, so there are also concerns about depression. It is necessary to verify whether the worsening of BI and MI distortions can be prevented by paying attention to the environment and mental health within two years of onset, when changes in one's perception of one's body may occur.

Age and number of years with the disease were related to the mental health subitems of the SEM. RA is four times more common in women than in men, and most cases occur in people between 40 to 60 years of age [23]. Depression is twice as common in women as in men, and is more prevalent in two age groups: young people and middle-aged people [12]. Furthermore, items related to cognitive function, such as the HDS-R, were also involved. As shown in the basic statistics, the HDS-R score was 29.3 ± 1.0, which was close to full score for all RA patients. The JASI-R, which assesses appearance schema, showed that of the

Table 1. Basic Attributes and Measurement Results

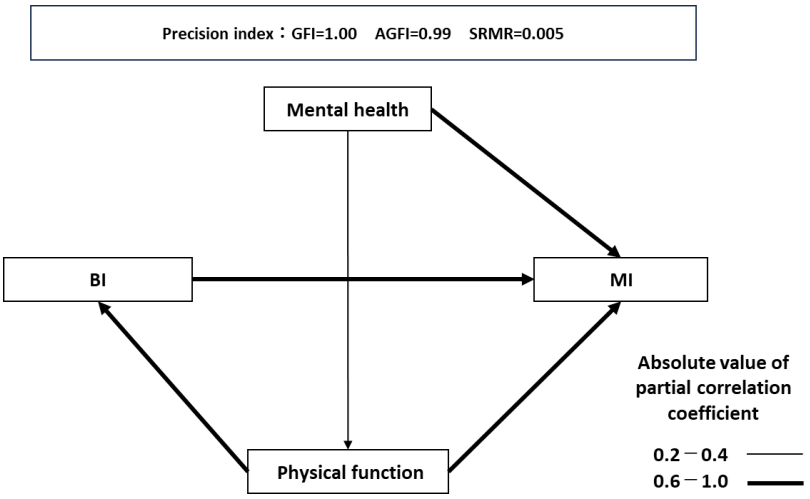
Item		Basic Statistics
Age (years)		59.5 ± 7.5
HDS-R (points)		29.3 ± 1.0
Years of disease (years)		9.7 ± 7.5
DAS28CRP		3.06 ± 1.02
TUG (second)		10.22 ± 3.02
JASI-R	characteristics of self-evaluation (points)	21.5 ± 4.7
	characteristics of motivation (points)	11.9 ± 2.8
HLJT	rate of correct answers (%)	79.4 ± 12.7
	time (second)	1.64 ± 0.78
JMIQ-R	KMI (points)	18.3 ± 4.1
	VMI (points)	19.4 ± 3.2
iTUG-gap (second)		4.71 ± 4.30

HDS-R: Hasegawa Dementia Scale-Revised; DAS28CRP: Disease Activity Score 28 C-reactive protein; TUG: Timed Up and Go Test; JASI-R: Japanese Version of the ASI-R; HLJT: Hand Laterality Judgement test; JMIQ-R: Movement Imagery Questionnaire-Revised Japanese Version; KMI: Kinesthetic Motor Imagery; VMI: Visual Motor Imagery; iTUG-gap: imagined Timed Up and Go test-gap.



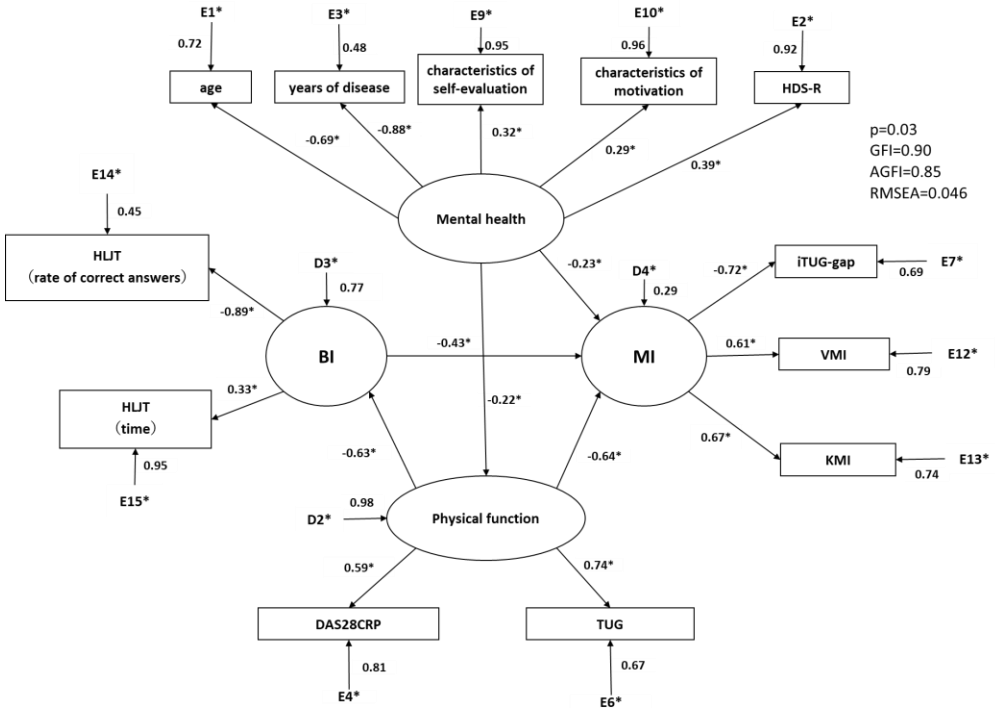
Figures 1. Correlation between measurements

GFI: goodness of fit index; AGFI: adjusted goodness of fit index; NFI; normed fit index; SRMR: standardized; BI: Body Image; MI: Motor Imagery; HDS-R: Hasegawa Dementia Scale-Revised; DAS28CRP: Disease Activity Score 28 C-reactive protein; TUG: Timed Up and Go Test; JASI-R: Japanese Version of the ASI-R; HLJT: Hand Laterality Judgement test; JMIQ-R: Movement Imagery Questionnaire-Revised Japanese Version; KMI: Kinesthetic Motor Imagery; VMI: Visual Motor Imagery; iTUG-gap: imagined Timed Up and Go test-gap.



Figures 2. Directed independence graph between cliques

GFI: goodness of fit index; AGFI: adjusted goodness of fit index; SRMR: Standardized Root Mean Square Residual; BI: Body Image; MI: Motor Imagery.



Figures 3. Causal modeling between variables (structural equation modeling)

E: error in observed; D: latent variable; GFI: goodness of fit index; AGFI: adjusted goodness of fit index; SRMR: Standardized Root Mean Square Residual; BI: Body Image; MI: Motor Imagery; HDS-R: Hasegawa Dementia Scale-Revised; DAS28CRP: Disease Activity Score 28 C-reactive protein; TUG: Timed Up and Go Test; JASI-R: Japanese Version of the ASI-R; HLJT: Hand Laterality Judgement test; JMIQ-R: Movement Imagery Questionnaire-Revised Japanese Version; KMI: Kinesthetic Motor Imagery; VMI: Visual Motor Imagery; iTUG-gap: imagined Timed Up and Go test-gap.

two categories of "characteristics of self-evaluation" and "characteristics of motivation," "characteristics of self-evaluation" was significant. It has been reported that women score significantly higher on both factors than men on this scale [24]. Among middle-aged and older RA patients, the "characteristics of self-evaluation" were more strongly related to mental health than the "characteristics of motivation" of trying to improve one's appearance. We believe this reflects a tendency to be concerned about how others evaluate them due to changes in body shape or posture.

The sub-items of BI using HLJT were rate of correct answers and time. Since the HLJT is a mental rotation task that grasps the degree of familiarity with one's own body and the formation of a body schema, it has been revealed that not paying attention to the body and denial of the body are related to the rate of correct answers and time on the HLJT [25]. It has been reported that chronic pain patients can suffer from depression and reduced attention due to the emotional aspects of pain [26-29]. In these analyses, the assessment of physical function, which is necessary to understand the current situation, was based on DAS28CRP and TUG, which are indicators of RA activity. DAS28CRP is an assessment that can grasp the disease activity state, which is an indicator of the momentum of the disease. Various findings have been reported regarding TUG as an assessment of lower limb function and balance ability [21], and it is also used as an indicator for identifying fall risk. We believe this is an appropriate means of comprehensively evaluating the physical function of middle-aged and elderly RA patients.

The subitems of MI included iTUG-gap, KMI, and VMI. iTUG-gap is used to measure the error of MI recall, and it has been reported that there is a correlation between iTUG and KMI[22]. The JMIQ-R is an assessment of the vividness of MI, analyzing whether the recollection of images is as vivid and clear as the actual experience. Research on elderly people has shown that the "KMI" of imagining oneself exercising and the "VMI" of observing others exercising are dissociated from the actual exercise of elderly people as they age [22]. Since the self-image that RA patients have is expected to become increasingly detached as they age, we believe that regular monitoring is necessary. Furthermore, interventions using MI in rehabilitation have been shown to be effective [30]. The time discrepancy between the image and the actual movement may make it difficult to mentally represent the movement, so training through image recall itself and observation is necessary. Our research has demonstrated that ADL ability and MI are related in RA patients [31], and these perspectives are considered necessary. Furthermore, these measurements are non-invasive and can be easily implemented in clinical practice for RA patients who have impaired joint movement.

In this study, we used directed independence graphs and SEM to gain insight into the sequence and causal relationships of exercise therapy. When considering exercise therapy to improve the mobility of RA patients who require long-term support, we believe that mental health, which focuses on MI and aims to improve motor skills while also considering psychological support, is also useful for RA patients. Furthermore, in terms of clinical practice, we believe that rehabilitation is imperative to prevent a decline in BI and MI. It is necessary to consider changes in the body from the early stages of the onset of RA and to prevent a decline in physical function.

This study was able to clarify the causal relationship between the mental health of RA patients and BI and MI, taking into account the time series.

However, this study was conducted at a single facility and only included female RA patients. In terms of mental health, the study only focuses on impressions of appearance and did not account for factors such as stress. In addition, detailed investigation of physical symptoms was not conducted, and is a possible extension to this work.

In the future, we would like to examine various factors related to RA chronologically and attempt to construct a new causal model.

FUNDING AND CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

LIST OF ABBREVIATIONS

BI: Body Imagery
DAS28CRP: Disease Activity Score 28 C-reactive protein
GM: Graphical Modeling
HDS-R: Hasegawa Dementia Scale-Revised
HLJT: Hand Laterality Judgement test
iTUG-gap: imagined Timed Up and Go test-gap
JASI-R: Japanese Version of the ASI-R
JMIQ-R: Movement Imagery Questionnaire-Revised Japanese Version
KMI: Kinesthetic Motor Imagery
MI: Motor Imagery
RA: Rheumatoid Arthritis
SEM: Structural Equation Modeling
TUG: Timed Up and Go Test
VMI: Visual Motor Imagery

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