Reliability and Validity of the Questionnaire to Determine the Biosocial Rhythms of Daily Living in the Disabled Elderly

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Abstract The questionnaire to determine the biosocial rhythms of daily living in the disabled elderly was newly developed. This questionnaire was aimed to evaluate a state of synchronization of biological rhythms in the disabled elderly. Eighteen items of the questionnaire relating to the synchronization of biological rhythms were finally selected by the test-retest method that was conducted for 68 disabled elderly living in a community with a duration of one year. The factor analysis showed that the questionnaire consisted of five factors: outdoor activities, ultradian rhythms, subjective evaluation of health status, social support, and sleep habits. The cumulative contribution rate of five factors was 53.2%. Reliability of the questionnaire was confirmed by a calculation of the Equal-length Spearman-Brown coefficients ranging from 0.60 to 0.80. Regarding the construct validity of the questionnaire, results of factor analysis showed five factors that were consistent with the synchronizers known in chronobiology. The total score of the questionnaire was significantly correlated to Barthel Index score and the competence score, suggesting that it partly reflects the activities of daily living of the disabled elderly. We conclude that a new questionnaire to determine the biosocial rhythm of daily living in the disabled elderly is useful to evaluate the biosocial synchronization of the disabled elderly because of its high reliability and validity.

Keywords: questionnaire, biosocial rhythm, disabled elderly, synchronization, reliability

Introduction

Personal effort and social support are indispensable for the disabled elderly to maintain a high level of activities of daily living (ADL) and to enjoy a healthy life as well as self-fulfilment in the community (Koyano, 1992). It has been reported that the state of synchronization of biological rhythms in the disabled elderly becomes unstable when the level of ADL decreases (Motohashi et al., 2000). Under the low level of ADL, the circadian rhythm amplitude of physiological indicators such as the heart rate changes (Motohashi et al., 1999a). The state of synchronization means that endogenous biological rhythms, such as body temperature rhythm and sleep-wake rhythm, exhibit periodicity with the same frequency of 24 hours of the external entrainment agents. This concept of synchronization of biological rhythms is now widely accepted in the human chronobiology (Haus and Touitou, 1992). The state of synchronization of the biological rhythms seems to be closely related to the ADL in the disabled elderly, and is potentially affected by external environmental entrainment factors, including social and behavioral factors, in the elderly. In the disabled elderly, the frequency of social contact and the quantum of social support are thought to be important (Motohashi et al., 1999b) as physical synchronizers such as bright light exposure (Okawa et al., 1993). Therefore, the state of synchronization of biological rhythms in the disabled elderly must be evaluated quantitatively from the biosocial aspects of rhythms in order to provide better home care services in the community. In our series of studies, we proposed the hypothesis that the biosocial rhythms of daily living in the disabled elderly are closely related to the ADL, especially the instrumental activities of daily living, and that the appropriate intervention of strengthening the biosocial synchronization increases the ADL in the disabled elderly (Motohashi et al., 1999b; Motohashi et al., 2000; Miyajima et al., 1997). In this study, we developed a questionnaire to determine the biosocial rhythms of daily living in order to evaluate the state of synchronization in the disabled elderly living in a community. The reliability and validity of the questionnaire are studied for its future practical use.

Materials and Methods

Development of the questionnaire

In order to develop a questionnaire to determine the biosocial rhythms of daily living (BRDL), five specialists
in community health for the elderly and one specialist in human chronobiology met for a brainstorming session on the contents of the questionnaire. Each participant proposed as many items as possible for the questionnaire and wrote them in complete sentences. During this process, the basic concept of synchronization of biological rhythms and the biosocial factors influencing the synchronization were fully explained by a researcher of human chronobiology: physical entrainment factors (bright light, sound, temperature and humidity), chemical entrainment factors (ethanol, benzodiazepins, theophylline), social entrainment factors (family, social support, social network, community participation, home help services), and individual factors (aging, genetic factor, morningness-eveningness preference, character, sensitivity to seasonal changes, time sensation, subjective health status). At the end of the first round of discussions, sixty items for the questionnaire were listed. In the second round of discussions, all the participants carefully examined the individual items. During this process, the items which were similar or were not essential for the questionnaire were excluded. In the end of the second round of discussions, forty-five items were finally listed. It was decided that those forty-five preliminary items would be used in our survey to develop a final version of the questionnaire. Three answers were prepared for each item of the questionnaire, and given the score of 0, 1, or 2 points. The score of 2 corresponded to the answer in which the effect of synchronization was fully explained by a researcher of human chronobiology. The other scores were attributed to the answers in which the effect of synchronization was partially or not explained at all.

The reliability of the questionnaire

The histogram of the total score in the questionnaire of the 68 disabled elderly who responded to the first survey was analyzed. First, the sharpness and skewing of the distribution were calculated. Then, a normal-probability plot was constructed in order to validate the normality. The reliability of the questionnaire was evaluated assuming that two parts of repetitive questionnaire have the same reliability. The Cronbach’s alpha coefficient showing internal-consistency reliability was also calculated.

Validity of the questionnaire

In order to evaluate the construct validity of the questionnaire, factor analysis using a principle component method was conducted from the data of the 18 item questionnaire selected by the reliability test. Rotation of the factorial axis was made by the Varimax rotation method, and factors were extracted on the basis of standardized factor loading values. An interpretation of each factor was made from the obtained data on factor loading values. The construct validity of the questionnaire indicates whether the interpreted factors
are compatible with the entrainment factors of biological rhythms.

Criterion validity was evaluated by the correlation analysis. For the biosocial rhythms of daily living, a gold-standard does not exist, because this questionnaire was developed for the first time to measure specifically the biosocial rhythms of daily living in the disabled elderly. However, the items included in this questionnaire partly overlap with those in other questionnaires used for measuring the activities of daily living. Therefore, a correlation study between the total score of the developed questionnaire and the scores of other measures of ADL was conducted. Barthel Index score which measures the physical activities of daily living in the disabled persons (Mahoney and Barthel, 1965), and the competence score that measures instrumental ADL and intellectual activity were used as a criterion. The correlation coefficients of the biosocial rhythms of daily living with Barthel Index score and the competence score were calculated.

The statistical analysis was conducted by SPSS for Windows Ver. 7.1.2.

Results

Development of questionnaire to determine the biosocial rhythms of daily living

As stated in materials and methods, eighteen items of the questionnaire were selected from the test-retest data. The items selected in the questionnaire were as follows: bedtime, rising time, quality of sleep, frequency of awaking during night sleep, daytime nap habit, regularity of meal times, frequency of urination, regularity of evacuation, frequency of going out, communication with other persons, persons who share worries, community participation, satisfaction in life, difference in activity pattern between weekdays and holidays, preference for outdoor activity, feeling that time goes by fast, communication with other people, subjective fatigue, and depressive mood. Five factors were extracted from the 18 items by factor analysis (Table 1). These were outdoor activities, ultradian rhythms, subjective evaluation of health status, social support, and sleep habits. The cumulative contribution rate of the five factors was 53.2%. A translated version of the questionnaire to determine the biosocial rhythms of daily living in the disabled elderly in a community is presented in Table 2.

Table 1 Result of factor analysis of 18 items of the questionnaire

<table>
<thead>
<tr>
<th>Items of questionnaire</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
<th>Factor 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>outdoor activity</td>
<td>0.54</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>community participation</td>
<td>0.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>difference in activity pattern</td>
<td>0.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>regularity of meal times</td>
<td>0.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>frequency of urination</td>
<td></td>
<td>-0.34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>regularity of evacuation</td>
<td>0.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>frequency of awaking during sleep</td>
<td>0.61</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>satisfaction in life</td>
<td></td>
<td></td>
<td>0.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>depressive mood</td>
<td></td>
<td></td>
<td></td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>subjective fatigue</td>
<td></td>
<td></td>
<td></td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td>habit of daytime nap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.58</td>
</tr>
<tr>
<td>frequency of going out</td>
<td></td>
<td></td>
<td></td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>communication with other persons</td>
<td>0.61</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>person who shares one's worries</td>
<td>0.62</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bedtime</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.37</td>
</tr>
<tr>
<td>rising time</td>
<td></td>
<td></td>
<td></td>
<td>-0.75</td>
<td></td>
</tr>
<tr>
<td>feeling that time goes by fast</td>
<td></td>
<td></td>
<td></td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td>quality of sleep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.71</td>
</tr>
</tbody>
</table>

<Interpretation of each factor>
Factor 1: outdoor activities
Factor 2: ultradian rhythms
Factor 3: subjective evaluation of health status
Factor 4: social support
Factor 5: sleep habits

Factor loading values after Varimax rotation method were shown. The highest absolute value among five factors was only shown in each item.
Questionnaire on Biosocial Rhythms

The histogram of the total scores in 68 disabled elderly who responded to the first survey is shown in Fig. 1. The total score ranged from 16 to 33. The sharpness of score of the histogram was 0.26 and the skewing of the distribution was −0.094. The result of Lillefors’ test was not significant (p=0.20), indicating that the observed distribution was not different from the normal distribution.

Calculation of total score of the questionnaire on biosocial rhythm of daily living for the disabled elderly:
(1) Time to go to bed: before 19 hours (0), from 19.1 to 20 hours (1), from 20.1 to 21 hours (2), from 21.1 to 22 hours (3), after 22.1 hours (4)
(2) Time to get up: before 5 hours (4), from 5.1 to 6 hours (3), from 6.1 to 7 hours (2), from 7.1 to 8 hours (1), after 8 hours (0)
(3) From question 3 to 18, scores are 0 for answer 1), 1 for answer 2) and 2 for answer 3).
(4) Total score of the questionnaire was a sum of each score from question 1 to 18.

Calculation of total score of the questionnaire on biosocial rhythm of daily living for the disabled elderly:
(1) Time to go to bed: before 19 hours (0), from 19.1 to 20 hours (1), from 20.1 to 21 hours (2), from 21.1 to 22 hours (3), after 22.1 hours (4)
(2) Time to get up: before 5 hours (4), from 5.1 to 6 hours (3), from 6.1 to 7 hours (2), from 7.1 to 8 hours (1), after 8 hours (0)
(3) From question 3 to 18, scores are 0 for answer 1), 1 for answer 2) and 2 for answer 3).
(4) Total score of the questionnaire was a sum of each score from question 1 to 18.

Statistical test on the normality of the total score distribution of the questionnaire

The histogram of the total scores in 68 disabled elderly who responded to the first survey is shown in Fig. 1. The total score ranged from 16 to 33. The sharpness of score of the histogram was 0.26 and the skewing of the distribution was −0.094. The result of Lillefors’ test was not significant (p=0.20), indicating that the observed distribution was not different from the normal distribution.
Reliability of the questionnaire

The reliability coefficients (Equal-length Spearman-Brown coefficient) of the five factors are shown in Table 3. They ranged from 0.60 to 0.80, and the Equal-length Spearman-Brown coefficient calculated from the 18 item data was 0.72. Cronbach’s alpha coefficient calculated from the 18 item data was 0.64.

Validity of the questionnaire

Figure 2 shows the correlation between the total score in the questionnaire and the Barthel Index score, which was statistically significant (r=0.90, p<0.01). This meant that total score of BRDL reflected the level of physical disability of the subject. Figure 3 shows the correlation between the total score in the BRDL questionnaire and the competence score, which was also statistically significant (r=0.41, p<0.05). The higher the total score in the questionnaire, the higher the competence score was. These two correlations suggest that the total score in the questionnaire reflects both the physical activities of daily living and the instrumental activities of daily living.

There was no significant sex difference in total score of BRDL (26.9 ± 5.2 for male and 25.6 ± 5.3 for female).

There was no significant correlation between age and total score of BRDL.

Discussion

A new questionnaire to determine the biosocial rhythms of daily living in the disabled elderly was developed in this study. This questionnaire measures the state of biosocial synchronization in the disabled elderly living in a community. Although many questionnaires have been developed to evaluate the health status and activities of daily living in the disabled elderly (McDowelle and Newell, 1996), few questionnaires determine the biosocial rhythms of daily living in the disabled elderly. The newly developed questionnaire highlights a new aspect of health determinant factor of regularity of biosocial rhythms of daily living in the disabled elderly. We have already reported that the sleep-wake rhythm is closely related to the physical fitness and competence level of stroke survivors living at home, and the importance of strengthening the synchronization of the sleep-wake rhythm to improve the competence of

<table>
<thead>
<tr>
<th>Factors</th>
<th>number of items</th>
<th>Equal-length Spearman-Brown coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>18</td>
<td>0.72</td>
</tr>
<tr>
<td>Social support</td>
<td>3</td>
<td>0.60</td>
</tr>
<tr>
<td>Subjective health</td>
<td>3</td>
<td>0.77</td>
</tr>
<tr>
<td>Sleep habits</td>
<td>4</td>
<td>0.80</td>
</tr>
<tr>
<td>Outdoor activity</td>
<td>3</td>
<td>0.78</td>
</tr>
<tr>
<td>Ultradian rhythm</td>
<td>5</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Fig. 2 The relationship between total score of the BRDL questionnaire and the Barthel Index score. The correlation was significant at p<0.01 (r=0.90).

Fig. 3 The relationship between total score of the BRDL questionnaire and the Competence score developed by Koyano et al. The correlation was significant at p<0.05 (r=0.41).
stroke survivors living in a community (Motohashi et al., 1999b). The newly developed questionnaire was intended to evaluate, within a short time, the state of synchronization of biosocial rhythms in the disabled elderly living in a community.

The reliability of the questionnaire was confirmed because the Equal-length Spearman-Brown coefficients varied from 0.60 to 0.80. This coefficient was calculated from a correlational analysis of the test-retest data from the questionnaire survey, and the reliability is considered to be high when the coefficient value is close to 1.0. Although there is no standard value of this coefficient for confirming the reliability, the range from 0.60 to 0.80 seems to be confirmatory of the reliability. For example, the reliability coefficients of Profile of Mood and State vary from 0.63 to 0.93 (Yokoyama et al, 1990). The reliability coefficients of the Scale for Quality of Care Management varied from 0.79 to 0.89 (Okamoto, 1999). Considering these reports on reliability studies, the reliability of the questionnaire to determine the biosocial rhythms of daily living appears to be fairly good.

Regarding the validity, we would like to consider it in terms of the construct validity and the criterion validity (McDowell and Newell, 1996). The construct validity of the questionnaire was analyzed by a factor analysis of the questionnaire. The factor structure of the questionnaire was clarified, and five factors were extracted. The five factors of outdoor activities, ultradian rhythms, subjective evaluation of health status, social support and sleep habits were all consistent with the synchronizer (entrainment factors) described in the text of chronobiology (Reinberg and Smolensky, 1983). Therefore, the factor structure of the questionnaire represented a wide range of synchronizers actually encountered in the disabled elderly living in a community. The explanations for the extracted factors are as follows. “Outdoor activities” measures the physical synchronization, mainly on the basis of bright light exposure, but also the social synchronization by community participation and week day rhythm. “Ultradian rhythms” measures the regularity in daily life such as meal times, urination and evacuation and their ultradian rhythmicities. “Subjective evaluation of health status” and “sleep habits” measure the biological synchronization of physiological variables as influenced by the external synchronizers. “Social support” measures the social synchronization of the disabled elderly living in a community. On the basis of these explanations, the questionnaire was thought to be a scale which comprehensively evaluates the biosocial rhythms of the disabled elderly living in a community from the standpoint of physical synchronization by bright light exposure, biological synchronization of the individual, and social synchronization.

Regarding the criterion validity, there is no gold-standard to evaluate the biosocial rhythms of daily living. Therefore, it is difficult to confirm the criterion validity. However, the correlation analysis between the total score in the questionnaire, and Barthel Index score and the competence score, was conducted in this study, because this questionnaire used to determine the biosocial rhythms of daily living also consisted of items related to the activities of daily living. The results showed that the total score in the questionnaire was significantly correlated to Barthel Index score and the competence score, suggesting that it at least partly reflects the activities of daily living. Although the developed questionnaire was not intended to evaluate the activities of daily living, the synchronization of biosocial rhythms in the disabled elderly living in a community is related to activities of daily living. The strength of correlation of the total score in the questionnaire was greater in the case of Barthel Index score than in that of the competence score, suggesting that the physical activities of daily living greatly affected the biosocial synchronization of the disabled elderly living in a community.

Although the reliability and validity of the questionnaire were confirmed in this study, they were only confirmed for the Japanese version of the questionnaire. The reliability and validity of the English version of the questionnaire were not examined. In the translation of the Japanese version of the questionnaire to other languages, sociocultural differences relating to the living conditions of the disabled elderly must also be considered. However, the selected items for the questionnaire and the factor structure seem to have a universality beyond sociocultural differences, which is expected to be confirmed in future studies.

This questionnaire to determine the biosocial rhythms of daily living was developed for evaluation of the synchronization of the disabled elderly living in a community. This questionnaire would be useful for the evaluation of activities of daily living of the disabled elderly and their needs for community care services. The basic concept of the questionnaire could also be extended to the healthy independent elderly living in a community. Another questionnaire to determine the biosocial rhythms of daily living in healthy independent elderly is also necessary in the future for health promotion of the healthy independent elderly living in a community.

We conclude that a new questionnaire to determine the biosocial rhythm of daily living in the disabled elderly is useful to evaluate the biosocial synchronization of the disabled elderly because of its high reliability and validity.

References


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