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*Original Article*

# Effects of Exercise Therapy and Nutrition Therapy on Patients with Possible Malnutrition and Sarcopenia in a Recovery Rehabilitation Ward

**Satoshi Takahashi[a], Takuya Kushibe[a], Yoshiteru Akezaki[b]*, and Norio Horiike[c]**

*Departments of [a]Rehabilitation Medicine, [c]Internal Medicine, Saiseikai Imabari Daini Hospital, Imabari, Ehime 794-0054, Japan, [b]Division of Physical Therapy, Kochi Professional University of Rehabilitation, Tosa, Kochi 781-1102, Japan*

**We compared the effects of an exercise intervention with that of exercise combined with nutrition therapy in patients with possible malnutrition and sarcopenia admitted to a recovery rehabilitation ward, and we examined the differences in the patients' physical function and activities of daily living (ADLs). There were 16 patients in the Exercise group with exercise therapy and ADL exercises, and 14 patients in the Combined intervention group with exercise therapy, ADL exercises, and nutrition therapy. The survey items were body weight, body mass index, grip strength, lower-leg circumference, gait speed, and ADLs, each of which was measured at the baseline and at 2 weeks, 4 weeks, and at discharge. Significant improvements in grip strength were observed in the Combined intervention group as follows: at 4 weeks > at 2 weeks ($p < 0.05$), and at discharge > baseline and 2 weeks ($p < 0.05$). There were no significant changes in the Exercise group, and an interaction was recognized in both groups. Comprehensive rehabilitation including nutrition therapy is necessary for patients with possible malnutrition and/or sarcopenia, as our results indicate that nutrition therapy in addition to exercise therapy has the effect of promoting improvements of physical function in such patients.**

**Key words:** sarcopenia, rehabilitation, exercise therapy, nutrition therapy, grip strength

Sarcopenia is a progressive decline in muscle mass, function, muscle strength, and performance. Patients with sarcopenia have been reported to have a decreased quality of life, decreased activities of daily living (ADLs) at hospital discharge, a worsened rate of discharge to their homes, and an increased risk of death [1-4]. The reported prevalence of sarcopenia in an elderly population admitted to an institution was 32.8%, and sarcopenia is often present in patients with a history of stroke or locomotor disorders [4]. In recovery rehabilitation wards, the prevalence of sarcopenia has been estimated as 50-53% [5, 6], and the proportion of inpatients with sarcopenia is high.

Individuals with sarcopenia have a lower protein intake compared to patients with non-sarcopenia [7-9]. Protein intake was reported to affect skeletal muscle mass and free fat mass [10-12], but it has also been reported that protein intake is not related to skeletal muscle mass [13, 14]. Although vitamin D has been reported to affect muscle fiber, muscle strength, and free fat mass [15-17], other studies indicated that vitamin D has less effect on skeletal muscle mass and muscle strength [18, 19]. The effects of protein and vitamin D intake on body composition and function are also unclear.

For patients with sarcopenia, interventions such as exercise therapy, nutrition therapy, and combinations of exercise therapy and nutrition therapy have been observed to be effective [20-23]. However, compared to

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*Corresponding author. Phone: +81-88-850-2311; Fax: +81-88-850-2323
E-mail: akezakiteru@yahoo.co.jp (Y. Akezaki)

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an intervention of exercise therapy alone, a combined intervention of exercise therapy and nutrition therapy did not show a significant improvement effect on muscle strength and skeletal muscle mass [20]. In a recovery rehabilitation ward, rehabilitation can be performed intensively, and patients with sarcopenia are required to perform interventions to improve their physical function and ability to conduct ADLs independently. Few studies have been performed in Japan to evaluate the effects of rehabilitation interventions for patients with sarcopenia in a recovery rehabilitation ward.

In this study, we compared the effects of an intervention with exercise therapy alone with those of a combined intervention of exercise therapy and nutrition therapy in patients with possible malnutrition and sarcopenia who were hospitalized in a recovery rehabilitation ward in Japan, and we examined the ability of the interventions to improve the patients' physical function and ADL performance.

## Patients and Methods

***Patients and methods.*** Of the 465 patients admitted to the recovery rehabilitation ward of our hospital in Ehime, Japan during the period from October 2018 to September 2020, patients with a body mass index (BMI) $\leq$20.0 kg/m$^2$ at admission were first selected as under-nutrition patients [24]. An evaluation was then performed to identify patients with sarcopenia. Sarcopenia is defined as a muscle mass $\leq$30 cm for males and $\leq$29 cm for females, using a calf circumference; gait speed $<$0.8 m/s; and/or muscle strength (*i.e.*, handgrip strength, $<$26 kg for males and $<$18 kg for females) [25,26]. In this study, we entered the patients who were admitted to the ward during the earlier period from October 2018 to March 2019 as the Exercise group, and the patients who were admitted from April 2019 to September 2020 were entered in the exercise therapy + nutrition therapy (Combined intervention) group. The subjects of the analysis were the 16 patients in the Exercise group and the 14 patients in the Combined intervention group whose measurements could be obtained continuously from the baseline to discharge (Fig. 1). The Exercise group was comprised of 1 male and 15 females, age 82.5 ± 6.9 years. The Combined group was comprised of 5 males and 9 females, age 79.1 ± 10.0 years. All of the patients were Japanese.

***Ethical approval statement.*** All procedures involving the subjects were performed under an approved protocol and in accordance with the standards of the Saiseikai Imabari Daini Hospital ethics committee (approval no. 2018-1) and with the 1964 Helsinki Declaration and its later amendments.

***Rehabilitation program.*** In the Exercise group, rehabilitation based on resistance exercise, balance exercise, and ADL exercise for the limbs and trunk was

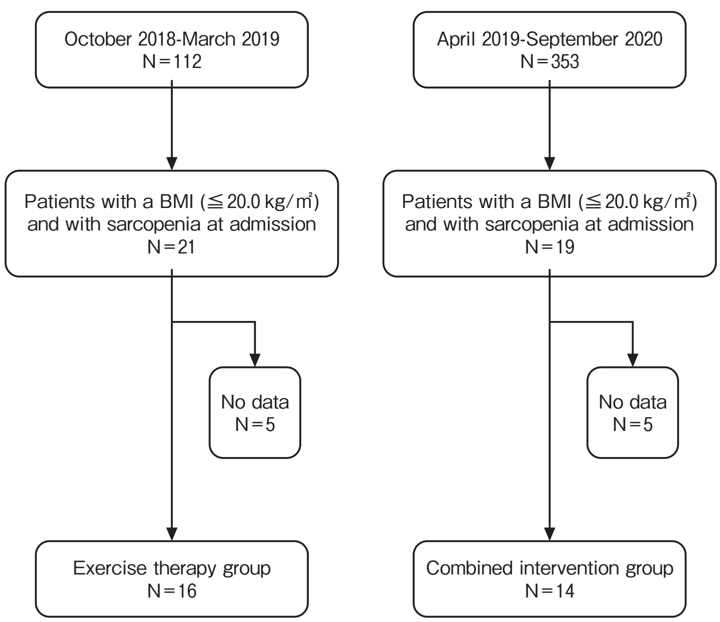


Fig. 1 Flowchart of the patient enrollment.

performed 7×/week for 60 min 2×/day. In the Combined group, in addition to the exercises performed as the exercise intervention, one bottle of Rehabilitation Jelly (Clinico Co., Tokyo) was ingested within 30 min after each exercise session. Rehabilitation Jelly is a dietary supplement containing vitamin D and protein containing branched chain amino acids (BCAAs). For their meals during hospitalization, both groups of patients received the same normal hospital meals and energy-free fluids. The survey items were body weight, BMI, grip strength, lower-leg circumference, gait speed, and ADL performance. Each item was measured at baseline, 2 weeks, 4 weeks, and discharge (6.6 ± 2.5 weeks).

***Grip strength.*** Grip strength was measured twice on each side by a grip strength meter (Takei Kikai Kogyo Co., Tokyo), and the maximum value was calculated for each side. The upper-limb side from which the maximum value was calculated at the baseline was set as the analysis target side. The measurement side at 2 weeks, 4 weeks, and discharge were the same side as the measurement side at the baseline.

***Lower-leg circumference.*** The circumference of each patient's lower leg was obtained by measuring the maximum circumference of the lower leg on the healthy side. The side for which the maximum value was calculated at the baseline was set as the analysis target side. The measurement side at 2 weeks, 4 weeks, and discharge were the same side as the measurement side at the baseline.

***Gait speed.*** For gait speed, the patient's fastest gait speed was measured. The time required to walk the middle 5 m of an 11-m indoor flat surface was recorded. The patients were asked to walk as quickly and as safely as possible without running. The patients performed the test twice, and the fastest time was recorded. Measurements were performed at the baseline, 2 weeks, 4 weeks, and discharge.

***Activities of daily living.*** The Functional Independence Measure (FIM) was used to measure the patients' ADLs. The FIM consists of a total of 18 items, 13 items for motor and 5 items for cognition, and each item is scored as 1-7 points. The ADLs were classified and analyzed in this study as the motor FIM and the cognitive FIM.

***Statistical analyses.*** Comparisons of the basic characteristics of the patients and of the baseline values in the Exercise and Combined intervention group were tested using the $\chi^2$ test and *t*-test. To investigate the impact of the interventions on each parameter evaluated, we performed a repeated two-way analysis of variance with each parameter as the dependent variable; the Greenhouse-Geisser F- and *p*-values were used to test for interactions between the group factors (Exercise and Combined intervention group) and time factors (baseline, 2 weeks, 4 weeks, and discharge). The Tukey test was used for separate multiple comparisons of the various parameters in each group at baseline, 2 weeks, 4 weeks, and discharge. SPSS software ver. 22.0 (IBM, Tokyo) was used to analyze the collected data. Probability ($p$)-values $< 0.05$ were considered significant.

## Results

The patients' diseases are listed in Table 1. As shown in Table 2, there were no significant differences between the Exercise and Combined groups at baseline regarding

Table 1 The patients' diseases

| Diseases | Number |
|---|---|
| Stroke | 5 |
| Fracture | |
| Pelvic fracture | 1 |
| Supracondylar fractures of the femur | 2 |
| Femoral neck fracture | 8 |
| Femoral intertrochanteric fracture | 4 |
| Disuse syndrome | 5 |
| Osteoarthritis | |
| Hip | 2 |
| Knee | 1 |
| Spinal subdural hemorrhage | 1 |
| Lumbar spinal stenosis | 1 |

Table 2 The patients' characteristics

| Parameters | Exercise group | Combined intervention group | *P*-value |
|---|---|---|---|
| Sex (male/ female) | 1/15 | 5/9 | 0.712 |
| Age (y) | 82.5 ± 6.9 | 79.1 ± 10.0 | 0.222 |
| Time from diagnosis to hospitalization (days) | 28.0 ± 11.5 | 35.2 ± 12.6 | 0.066 |
| Length of stay (days) | 52.1 ± 17.8 | 53.8 ± 21.2 | 0.781 |

the patients' age, weight, BMI, time from disease onset, grip strength, lower-leg circumference, gait speed, motor FIM, or cognitive FIM scores. Table 3 shows the comparison results of the survey items in the two groups. The patients' weights in the Exercise group showed significant improvement at 4 weeks compared to the baseline, and at discharge compared to the baseline ($p<0.05$); however, no interaction was observed.

The BMI in the Exercise group showed significant improvement at 4 weeks compared to the baseline, and at discharge compared to the baseline ($p<0.05$). The Combined intervention group showed significant improvement at 2 weeks compared to the baseline, at 4 weeks compared to the baseline, and at discharge compared to the baseline ($p<0.05$). No interaction was observed.

The lower-leg circumference in the Exercise group showed a significant improvement 2 weeks versus baseline, at 4 weeks versus baseline, and at discharge versus baseline ($p<0.05$). The Combined group showed significant improvements in lower-leg circumference at 2 weeks compared to the baseline, at 4 weeks compared to the baseline and 2 weeks, and at discharge compared to the baseline and 2 weeks ($p<0.05$), although no interaction was detected.

The grip strength in the Combined group showed significant improvement 4 weeks compared to 2 weeks, and at discharge compared to the baseline and 2 weeks ($p<0.05$). There were no significant changes in grip strength in the Exercise group, and the interaction of group and time were recognized.

The gait speed in the Exercise group showed significant improvement at 4 weeks compared to the baseline, and at discharge compared to the baseline ($p<0.05$). The Combined group showed a significant improvement at 2 weeks versus the baseline and at discharge versus baseline ($p<0.05$). No interaction was identified.

The motor FIM in the Exercise group showed significant improvement at 2 weeks compared to the 2 weeks, 4 weeks compared to the baseline, and discharge compared to the baseline, 2 weeks, and 4 weeks ($p<0.05$). The Combined group showed significant improvement at 2 weeks versus baseline, at 4 weeks versus baseline and 2 weeks, and discharge versus baseline, 2 weeks, and 4 weeks ($p<0.05$). However, an interaction was not observed.

The cognitive FIM in the Combined group was significantly improved at 4 weeks compared to the baseline, and at discharge compared to the baseline and 2 weeks ($p<0.05$). There were no significant changes in the Exercise group. However, an interaction was not observed.

## Discussion

We compared the physical function and the ability to

Table 3 Baseline, 2 weeks, 4 weeks, and discharge data of the Exercise and Combined intervention groups

| Parameters | Group | Baseline | 2 weeks | 4 weeks | Discharge | Interaction F-value | Interaction *P*-value |
|---|---|---|---|---|---|---|---|
| Body weight (kg) | EG | 39.5 ± 5.7 | 40.0 ± 5.7 | 40.2 ± 5.9[b] | 40.5 ± 5.9[c] | 0.076 | 0.973 |
| | CIG | 41.4 ± 6.2 | 42.1 ± 7.0 | 42.2 ± 6.6 | 42.4 ± 6.4 | | |
| BMI ($kg/m^2$) | EG | 17.6 ± 1.9 | 17.9 ± 2.0 | 17.9 ± 2.0[b] | 18.1 ± 2.1[c] | 0.429 | 0.733 |
| | CIG | 17.2 ± 1.3 | 17.6 ± 1.4[a] | 17.7 ± 1.4[b] | 17.8 ± 1.4[c] | | |
| Grip strength (kg) | EG | 13.2 ± 4.8 | 13.6 ± 4.2 | 13.6 ± 4.6 | 13.7 ± 4.8 | 4.052 | 0.010 |
| | CIG | 15.0 ± 5.7 | 15.7 ± 6.0[d] | 17.3 ± 6.3 | 16.8 ± 6.0[e] | | |
| Circumference of the lower leg (cm) | EG | 26.3 ± 2.0 | 26.6 ± 2.1 | 26.9 ± 2.0[b] | 27.3 ± 2.3[c] | 0.296 | 0.829 |
| | CIG | 27.2 ± 1.4 | 27.5 ± 1.4[d] | 28.0 ± 1.5[b] | 28.4 ± 1.5[c,e] | | |
| Gait speed (m/sec) | EG | 0.9 ± 0.5 | 1.2 ± 0.5 | 1.3 ± 0.4[b] | 1.5 ± 0.5[c] | 1.667 | 0.180 |
| | CIG | 1.1 ± 0.7 | 1.3 ± 0.7[a] | 1.3 ± 0.6 | 1.4 ± 0.6[c] | | |
| Motor FIM (score) | EG | 53.6 ± 14.7 | 58.7 ± 16.4[a] | 67.4 ± 16.7[f] | 74.4 ± 15.5[c,e] | 0.614 | 0.608 |
| | CIG | 58.7 ± 9.9 | 65.1 ± 10.9[a,d] | 72.7 ± 8.6[b,f] | 77.6 ± 7.3[c,e] | | |
| Cognitive FIM (score) | EG | 27.7 ± 8.8 | 27.8 ± 8.8 | 28.3 ± 8.5 | 29.1 ± 8.0 | 0.148 | 0.931 |
| | CIG | 28.3 ± 6.7 | 28.7 ± 6.8 | 29.1 ± 6.7[b] | 29.6 ± 6.3[c,e] | | |

BMI, Body Mass Index; FIM, Functional Independence Measure; EG, Exercise group; CIG, Combined intervention group
a, $p<0.05$, baseline vs 2 weeks; b, $p<0.05$, baseline vs 4 weeks; c, $p<0.05$, baseline vs discharge; d, $p<0.05$, 2 weeks vs 4 weeks; e, $p<0.05$, 2 weeks vs discharge; f, $p<0.05$, 4 weeks vs discharge

engage in ADLs of patients with possible malnutrition and sarcopenia who received an exercise intervention or a combined intervention of exercise and nutrition therapy in a recovery rehabilitation ward. Both groups of patients showed improvement in their physical function and ADLs, and the Combined intervention group showed a significant improvement in grip strength compared to the Exercise group.

Studies of progressive resistance training in older institutionalized adults have reported improvements in muscle strength, balance, and gait speed [27]. In an investigation of healthy elderly people, 12-24 weeks of resistance exercise resulted in an increase in lean body mass, muscle hypertrophy, and muscle strength [20]. In the present study, both the Exercise group and the Combined intervention group showed significant improvements in lower-leg circumference, gait speed, and FIM by the time of their discharge compared to the baseline. Muscle hypertrophy, walking ability, and ADL improvement were obtained because both the Exercise and Combined groups included rehabilitation aimed at improving physical function and ADLs.

Both a combined exercise + nutrition intervention and the exercise intervention were reported to be effective for improving the patients' normal gait speed, but the interventions had no effect on limb skeletal muscle mass, lean fat mass, grip strength, knee extension muscle strength, or maximum gait speed [20]. In our present investigation, the Combined intervention group achieved significantly improved grip strength compared to the Exercise group. The combination of exercise and nutrition interventions has the effect of stimulating muscle protein synthesis and improving sarcopenia through low-intensity strength training and the intake of BCAAs, leucine, essential amino acids, whey protein, and vitamin D [28, 29]. In our study, in addition to exercise therapy and ADL exercises for improving physical function, the ingestion of protein including BCAA and vitamin D was effective for increasing the patients' muscle strength. The combined effect of nutrition therapy in addition to exercise may have been obtained because the patients in this study had possible malnutrition and sarcopenia. In addition, grip strength has been shown to be a surrogate of overall muscle strength [30] and is a predictor of ADL disorders and future disability in the elderly [31]. Therefore, a combined intervention of exercise therapy and nutrition therapy could lead to improvements in both ADL disability and future disability.

Protein plus vitamin D intake has been reported to improve skeletal muscle mass and fat mass [10-12, 15-17], but there are also reports that no significant improvement effect was obtained by this intake [13, 14, 18, 19], and thus the effect is not clear. In the present study, although the grip strength values were significantly different between the Exercise and Combined groups, the improvements in weight, BMI, and lower-leg circumference were not significantly different between the two groups. The measurement method that we used in this study could not clarify the effect of the combined nutritional intervention, and the results may differ with the use of objective evaluations such as a body composition analyzer or dual-energy X-ray absorptiometry.

There are some study limitations to address. The number of patients was small, and the patients' diseases were not uniform. We did not establish the precise nutritional status of the patients. In addition, muscle mass cannot be measured by objective evaluation methods such as a body composition analyzer and dual-energy X-ray absorptiometry. Moreover, we were not able to assess the interventions' effects on lower-limb muscle strength (which affect an individual's ability to perform ADLs) because the lower-limb muscle strength was not evaluated. Further research is needed to examine these issues.

In conclusion, we compared the physical function and ADLs of patients with possible malnutrition and sarcopenia who underwent an exercise intervention or a combined intervention of exercise and nutritional therapy. The combined-intervention group showed a significant improvement in grip strength compared to the exercise-alone group. Comprehensive rehabilitation including nutrition therapy thus appears to be necessary for patients with possible sarcopenia, as our findings indicate that nutrition therapy in addition to exercise therapy has the effect of promoting improvement of physical function in such patients.

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