表1 最大歩行速度80m毎分を基準とした身体機能の比較

	80m毎分以上			80m毎分未満		
	平均値	標準偏差	n	平均値	標準偏差	n
10m通常歩行速度（m/分）	83.4	12.5	742	51.1	10.7	45
10m最大歩行速度（m/分）	120.3	19.9	743	64.9	11.7	47
膝伸展トルク（Nm）	76.4	26.4	734	49.0	17.7	43
TUG（秒）	5.34	1.11	737	11.08	4.53	43
開眼片足立ち時間（秒）	44.2	21.6	742	16.2	19.3	46

TUG：Timed UP & Go Test

腰から”と一般にもいわれるように，移動能力の低下は，その後の生命予後のみならず，要介護状態とも密接な関連を示す．虚弱高齢者は歩くことが難しい．これは，誰にとっても自明ではあるが，運動指導の際にこの特徴を十分に考慮しているとは言い難い．

たとえば，従来の虚弱高齢者の運動指導はスクワットやラジオ体操など，いずれも立位で行われる運動が選択されていた．しかしこれは妥当とはいえない．虚弱高齢者では，膝関節の伸展筋力が低く，臨床的には膝折れ現象を多く観察する．すなわち，立位の保持，立位の動作は，虚弱高齢者にとってはすでに過負荷になると考えられるにもかかわらず，これへの考慮がみられなかった．一方，類似した障害像を対象とする，デイサービスなど介護施設では，座位で行うタオル体操や風船バレーなどが選択されてきた．これは，立位での運動とは異なり，過負荷ではないものの，逆に無負荷の運動といえ，一次的な課題である歩行能力の改善には直接的な効果を望めない．

表1は，われわれの地域在住高齢者の身体機能を要約したものであるが，前述の虚弱高齢者の定義のひとつ，すなわち最大歩行速度80m毎分未満を基準に，虚弱高齢者像を明確にすれば，介入の糸口がみつかる．Timed Up & Goテストに元気な高齢者の2倍以上の時間を要し（表1），膝関節の伸展トルクが歩行可能者のほぼ下限値である49Nしか発揮できないものが対象なのである（図1）．いわゆる健康体操などがいかにも難しい対象者であることが理解できよう．

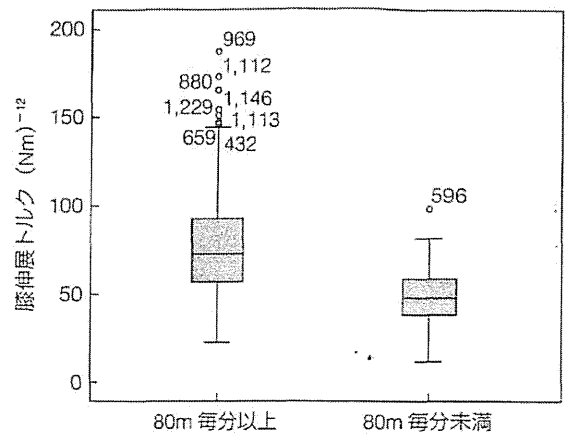

図1 最大歩行速度80m毎分を基準にしたときの膝関節伸展トルクの箱ひげ図

3. 虚弱高齢者の運動指導の特異性

運動に対する効果の特異性はよく知られるところである．持久力を目的としたトレーニングを指導すれば持久力が，筋力を目的としたトレーニングを指導すれば筋力がといったように，運動指導の内容に特異的に，機能の改善が図られる．虚弱高齢者は移動機能に機能低下を認めるわけであるから，移動能力を高める特異的な介入が必要である．

すなわち下肢，中でも，抗重力筋に対する筋力トレーニングは必須である．前述の通り，下肢の筋力低下が顕著な対象であり，歩行機能を改善するには筋力の向上が必要である．

また，衣笠[4]によれば，バランス機能が高齢期に最も早く機能低下がみられるとされており，バランス機能のトレーニングも必要になる．表1で

表2 最大歩行速度80m毎分を基準とした痛みの頻度の差

普段の痛み		80m毎分以上		80m毎分未満	
		度数	%	度数	%
腰	なし	445	60.0%	15	31.9%
	あり	297	40.0%	32	68.1%
膝	なし	493	66.4%	15	31.9%
	あり	250	33.6%	32	68.1%

は，元気な高齢者の片足立ち時間が平均で44秒なのに対し，最大歩行速度が80mを下回る高齢者では，16.2秒と約3分の1である．バランス能力を高めるトレーニングも必要と考えられる．

さらに，痛みの問題も考慮されなければならない．同じ地域在住高齢者からのデータであるが，虚弱高齢者では腰の痛み，膝の痛みがあるのは68%であり，いずれも元気な高齢者と比較して統計学的に有意に痛みの頻度が高い（表2）．痛みの改善やそれが望めないとしても，痛みの対処を含む運動指導が求められる．

4. 包括的高齢者運動トレーニング (comprehensive geriatric training: CGT)

CGTとは，虚弱高齢者を対象とした，筋力，バランス，機能的動作の包括的な運動トレーニングである．このトレーニングは，体力の諸要素を包括的に含むものであるが，特に機器を用いた筋力増強トレーニング（高負荷低反復筋力トレーニング）を特徴としている．多くの筋力トレーニング機器は，座位で目標となる筋肉を鍛えることができるように設定されており，立位保持が難しい特徴をもつ虚弱高齢者の筋力の増強のためには，必要不可欠と考えられる．たとえば，体重が60kgあれば，60kgを支える膝の力が必要であるが，それが十分でないために，骨性の支持によって立位を保っている高齢者にとっては，過負荷となる．一方，現在の高齢者向けの筋力トレーニング機器は，最低負荷が5kg程度に設定されており，5kgでトレーニングを行えば，体重の12分の1の負荷からトレーニングを開始することができる．すなわち，筋力トレーニング機器は，虚弱高齢者が安全，効果的に筋力を増強するための必須の補助装置であるといえる．

1) 目標設定

CGTを行う際には，筋力増強や機能向上が目的化しないように，生活機能の課題を明らかにし，それを改善するための手段として，CGTがあることを，対象者とともに共有する必要がある．このために，日常の生活行為の中で，一人で難しい生活行為の中でCGTによって，改善が期待できる項目を1つ，何とか一人でできている生活行為の中でCGTによって，楽にできるようになることが期待できる項目を1つ程度選び出し，それを目標とする．

2) アセスメント

CGTでは，事前・事後に系統的な客観指標による評価が行われる．評価基準は他に譲るが[5]，運動機能を包括的に評価し，重点的に介入すべき運動機能を明らかにして，介入を行う．また，健康関連QOLやCGTの効果を貨幣価値に換算するなどして，効果，効用，便益の3領域からCGTの効果を判断できるようにする．加えて，visual analog scale（VAS）などを用い，痛みの評価も行う．

3) 痛みの評価方法

(1) T1, T2, T3

痛みの重症度を痛みに関する3つの時間（TはTimeのT）をもって評価する．T1とは，動きはじめてから痛みが出現するまでの時間をいう．急性期の反応性の強い痛みでは，動きとともに痛みが発生する（T1=0）．このような場合は，運動トレーニングの対象とはならない．同様にT2とは，痛みがはじまっても運動を続けられる時間をいう．たとえば，ウォーキングなどでも，10分間で痛みがはじまり（T1=10），それでも20分は歩き続けられる（T2=20）といったことが

生じる．しかし，反応性が高い場合は，一旦痛みはじめると，ただちに続けられない（T2＝0）という場合がある．このような場合も運動トレーニングの対象とはならない．運動トレーニングをしてもよいのか，いけないのかの判断は，T1またはT2が0でないことが条件となる．

一方，T3は，一旦痛み出したものが元の状態に戻るまでの時間である．反応性の低い痛みでは，痛みが生じてもすぐに回復する．しかし反応性の高い痛みは，回復に時間がかかり，1日以上を要する場合もある．このような場合は，運動の種目，量を慎重に見極め，保護的な運動トレーニングを行う．臨床的には30分を目安に，30分以内で痛みが元の状態に戻るようであれば，そのまま運動トレーニングを行い，これ以上回復に時間を要する場合では，運動トレーニングの量と質を制限する．

(2) P1，P2

虚弱高齢者の痛みは，動きとともに発生するものが多い．関節可動域が主観的な痛みの客観的な表現系となることが多い．このとき，多くの対象者は動かしたときに痛みでそれ以上動かせなくなる角度（これをP1とする）を評価基準とする場合が多い．臨床的に観察する難治性の50肩の対象では，常にP1を確認する行動をとる．これは，治癒しようとしている炎症をさらに再燃させる刺激となり，避けなければならない．そこで，CGTではこれに変わって痛みがはじまる角度（これをP2と呼ぶ）を評価する．CGTにおいてP1は禁忌であり，P2を評価する．このP2がトレーニングによって可動域が広がれば，その種目，負荷量は適当と判断し，逆に狭まれば，その種目，負荷は過負荷であると判断する．

(3) VAS

白紙に100mmの直線を描き，左の端を無痛状態，右の端をこれまで経験した最もひどい痛みとしたときの，現在の痛みに相当する分断線を入れる方法である．この方法は，運動トレーニングによって痛みが増悪するのか，改善するのかを，継続的にモニターするのに優れている．運動トレーニングを実施する毎に今の痛みを記録しておき，横軸をトレーニング日，縦軸をVASの読み取りとした，折れ線グラフ型で示すことによって，運動トレーニングの痛みに対する影響を客観的に判断することができる．虚弱高齢者の痛みの場合，運動トレーニングによって痛みが軽減することが多いが，これが増悪する場合などは，ひどい痛みではなくても整形外科医など専門職に相談する．

4) プログラム作成

(1) 個別プログラム

虚弱高齢者とはいえ，一般に高齢者は運動機能の個人差が大きいことから，集団でのプログラムであっても，個別のメニューを作成する．体力のレベル，痛み，身体アライメント，バランスのアセスメントに基づき，運動の種類，回数，手順を選択する．

(2) 期分け

CGTは，虚弱高齢者を対象とすることから，コンディショニングに十分な期間を配分する．この期間は，低負荷高反復のトレーニングを行い，組織の栄養状態，弾性を高めるとともに，対象者の特異的な運動への準備状況を整える．これをコンディショニング期とする．次に，先にも述べたように，虚弱高齢者では筋力が増強することが回復への1つの要件となる．したがって，第2期目は筋力増強期とする．この期間は，過負荷の原則に基づき，一人ひとりの最大挙上力を把握し，この力の60％以上の負荷を目安にし，高負荷低反復の運動を行う．ただし，最大挙上力の見極めは，慎重を要し，代償運動を伴わないスムーズな動作を判断基準に負荷量を見極める．代償運動は，目的とする筋力の負荷を小さくするだけでなく，怪我の危険を高める．筋力トレーニング機器は，レッグプレス，レッグエクステンション，ヒップアブダクション，ローイングを基本とし，それぞれの対象者が10回3セットの運動を行っても1時間30分を超えない範囲で，種目を選択する．

第3期目は，このようなトレーニングによって得られた運動機能を，生活行為に活かすことを目

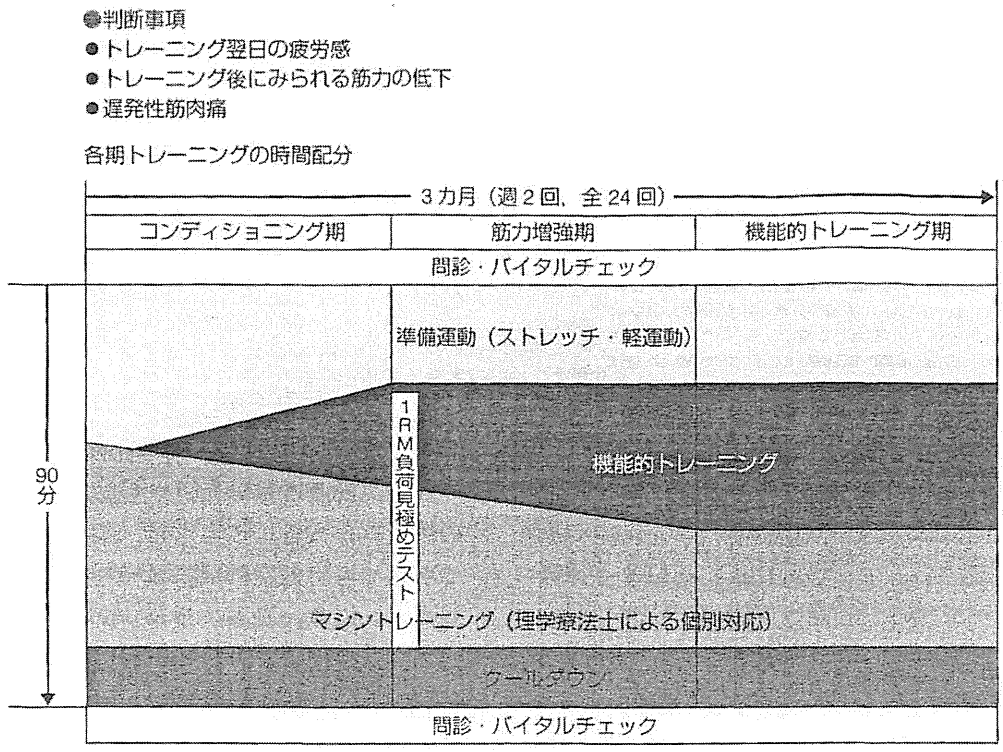

図2　CGTの期分け（各1カ月）（大渕ほか，2006[5]）

標にする．目標として設定した生活行為を頼りに，それを実現するための動作を明らかにし，その動作を反復してトレーニングを行う．歩行機能低下者では，歩くときの膝の協調した運動が難しくなっているものが多いので，ニーベントウォーク（接地→膝の屈曲→膝の伸展→膝の屈曲→反対側の接地と動作を分け歩行する）などを用いると，歩行動作がよくなる．また，体幹の筋力が低下している場合も多く，体幹筋の協調的収縮，いわゆるコアマッスルトレーニングなども有効である．これらを図2[5]のように期分けにあわせ，その配分を変えて実施する．

5）実　施

個別のメニュー作成を強調したが，その後の継続等の効果を狙い，基本的に集団で実施する．しかし，虚弱高齢者では個別の目配りが必要であるため，一般に行われる大人数での体操指導は行うべきではない．一人ひとりの課題を共有しながら，変化をフィードバックしていくことができるように8名程度のグループで実施することが望ましい．CGTでは基本的に4機種の筋力トレーニング機器を用いることとしているので，8名程度が最適なグループ構成数となる．これに対し，指導者は理学療法士等1名，介護予防運動指導員1名，運営補助1名で行う．

1回のプログラムは約90分で構成し，準備運動，マシントレーニング，機能的トレーニング，クールダウンに要する時間を，期分けの計画に基づいて変化させる（図3）．この図では，機能的トレーニング期に移行するにしたがってマシントレーニングの時間が減少するようにみえるが，これは乗り降りや機器の設定がスムーズにできることになって，実施効率が上がるためであり，マシントレーニングの機種や繰り返し回数が減少するわけではない．

痛みがある場合は，介護予防運動指導員や理学療法士が詳細なアセスメントを行い，マシントレーニングに先立って運動療法を行う．

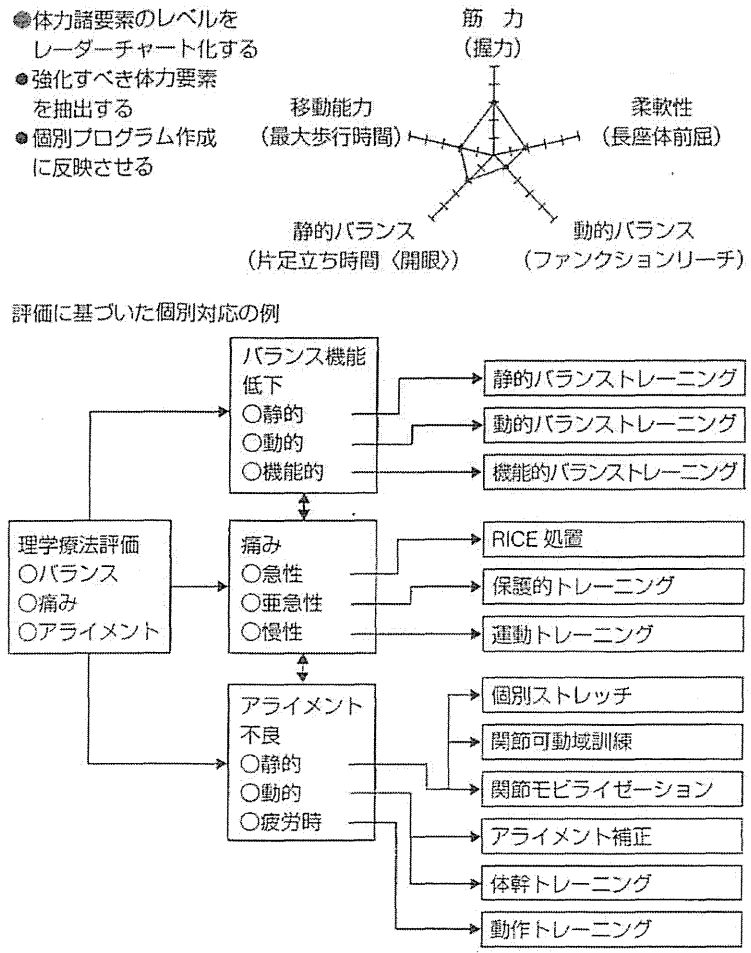

図３　アセスメントに基づく個別メニュー（大渕ほか，2006[5]）
RICE：rest（安静），ice（冷却），compression（圧迫），elevation（挙上）

おわりに

虚弱高齢者の運動指導は，運動の方法を指導することではない．運動の指導を通して，退行期にある心身の取り扱い方を知ることである．高齢期の運動では，“自立”が強調されるが，むしろ“自律”が大切なのである．そのためには集中的にトレーニングを行い，その変化を指導者が対象者に確認することが有用である．運動指導に十分に従ったとしても，いずれ心身機能の低下がみられることは避けられない．大切なことは，心身機能の低下といかにうまくつきあっていくかということにある．痛いのが怖いからといって出歩かなくなってしまったり，疲れやすいからといって休んでばかりいれば，ますます状態が悪化する．痛いときにはどうすればよいのか，疲れたときにはどうすればよいのか，コーピング方法の豊富さが豊かな高齢期の生活をもたらす．

筆者は仕事柄，多くの高齢者の運動指導の現場に立ち会うことがあるが，最も問題に感じるのは，指導者への信奉をつくるような指導をしている場合である．指導者も腕のよい指導者ということで，鼻を高くしているが，このような運動指導は，依存であり自律ではない．自分の体の弱点は何で，どのようにモニタリングをし，どのように調子を整えていくのか，むしろ指導者から離れたときが指導の真価が発揮されると考えて運動指導に当たるべきである．繰り返しになるが，虚弱高齢者の

運動指導とは，リピーターが多いかどうかで判断されるのではない．むしろ，リピーターが少ないことが求められるのである．

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Applied nutritional investigation

Novel diet for patients with impaired mastication evaluated by consumption rate, nutrition intake, and questionnaire

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ABSTRACT

Objective: "iEat®" (EN Otsuka Pharmaceutical Co. Ltd.; study diet), a food product that resembles an ordinary meal in appearance but is cooked to soften, was compared with foods provided to patients with impaired mastication (modified traditional diet) to investigate the influence of the appearance of foods on the consumption rate, dietary nutrition intake, and satisfaction level.

Methods: After serving the study participants the modified traditional diet on days 1 and 2, the study diet on days 3, 4, and 5, and the modified traditional diet on days 6 and 7, the consumption rates were measured by weight difference. The amounts of dietary nutrition intake were calculated from the consumption rates. Satisfaction levels were evaluated by a questionnaire completed by the participants and their health care professionals after each meal.

Results: No significant difference in consumption rates was observed between the study diet and the modified traditional diet. The amounts of dietary nutrition intake of energy and protein were significantly higher for the study diet than for the modified traditional diet. The study diet showed higher satisfaction levels in terms of "appearance" when evaluated by the participants, and "joy of eating" and "overall satisfaction level" when evaluated by the health care professionals.

Conclusion: The study diet has potential to become a new dietary option for patients with impaired mastication.

Introduction

The elderly Japanese population ages ≥65 years comprised 29.80 million people as of September 2011 and accounted for 23.3% of the total population, comprising an increase of 240,000 persons or 0.2% compared with the previous year. Both the population and percentage reached their highest historic levels [1]. The elderly are known to have nutrition disorders of varying severity, which are caused by three major factors, namely physical, psychological, and environmental factors. Mastication difficulty has been reported as a physical factor [2]. Soft and easily chewable foods are preferred by patients with impaired mastication, but these foods were reported to be low in nutrition density, based on the content of nutrients per unit weight [3]. Tanaka et al. [4] reported reduced amounts of intake of total energy, protein, and lipids, as well as reduced serum albumin levels, associated with impairment of mastication. It also has been reported that mastication difficulty results in reduced dietary nutrition intake [5–8], and lowers not only the quantity and quality of the nutritional intake and nutritional indices, but also quality of life in terms of the diet and social life of the elderly [9,10].

Regarding diets for mastication difficulty, methods for cooking various items such as porridge and minced or blended foods, the modified traditional diet of this study, are widely used at medical institutions, nursing care facilities, and homes. The limited ability of these methods to soften meats and fish, and the time and effort involved in the preparation, are considered problematic. It is also a fact that meals prepared by these methods do not retain the appearance of the original ingredients, and are not appetizing to patients with impaired mastication or their families.

This multicenter joint study was performed to investigate the consumption rate, changes in intake of energy, protein, lipids, carbohydrates, and sodium based on the consumption rate, and changes in satisfaction level according to a questionnaire to elucidate the influence of the appearance of a diet.

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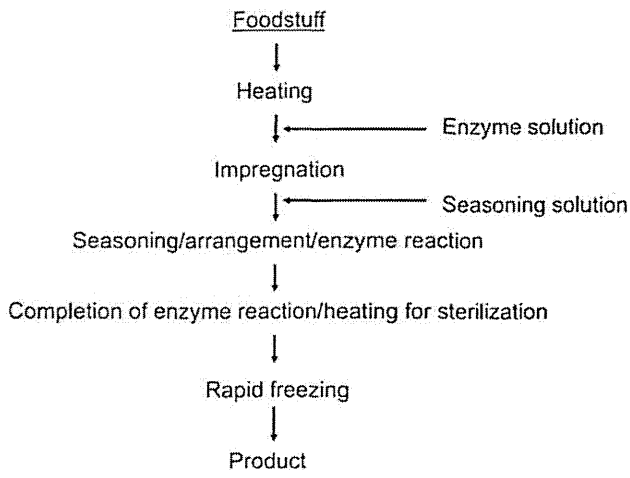


Fig. 1. Manufacturing process of the study diet (outline).

Methods

Study diet

Method for manufacturing the study diet

Figure 1 shows the outline for the manufacturing process of "iEat®" (EN Otsuka Pharmaceutical Co. Ltd.; study diet). Different methods were used for vegetable foodstuffs, such as vegetables and legumes, and animal foodstuffs, such as meat and fish. The technique used for softening the study diet is called enzyme homogeneous permeation, and is illustrated in Figure 2.

Evaluation of appearance and measurement of hardness

Figure 3 shows the appearances of a blender diet (modified traditional diet) and the study diet. The study diet retained similar appearances and colors to ordinary foods cooked by typical methods, and the foods were barely distinguishable in appearance, whereas the blender diet showed a tremendous change in appearance.

Table 1 lists the hardness values of the components of *Chikuzenni* (simmered chicken and vegetables), a study diet meal, compared with those of typically prepared components. The difference in hardness ranged by 12-fold between carrots, which were the softest, and bamboo shoots, which were the hardest. On the contrary, all of the components were of similar softness in the study diet. The physical property of hardness was measured by a creep meter (RE2-33005B; Yamaden) in accordance with the test method provided in the criteria for foods for mastication disorder (2009) [11].

Nutrients of the study diet

Table 2 lists the nutrients contained in each study diet menu. The nutrients were calculated based on the fifth revised and enlarged version of the Standard Tables of Food Composition in Japan [12].

Method of warming meals before serving

The study diet consisting of rice, main dishes, and side dishes was stored frozen and subsequently thawed/heated at 80°C for 30 min in a steam convection oven or steam microwave oven.

Participants

The study participants were Japanese inpatients under nutritional management for mastication difficulty or residents of nursing care facilities whose energy requirement was evaluated at 1200 kcal to 1500 kcal, but for whom the actual mean consumption rate of a modified traditional diet was approximately ≤75%, although the required amount was served. Consumption may or may not have been assisted.

Survey method

A multicenter joint group comparison study was performed to compare the modified traditional diet and the study diet. The study sites and investigators are listed in Table 3.

Breakfast, lunch, and dinner were served during the study period of 7 consecutive days. The subjects were served the modified traditional diet on days 1 and 2, the study diet on days 3, 4, and 5, and the modified traditional diet on days 6 and 7. The consumption rate was calculated for each meal by the weight differential method at breakfast, lunch, and dinner during the study period. The amounts of intake of energy, protein, lipids, carbohydrate, and sodium were calculated based on the consumption rate. The questionnaire was given after each meal during the study period. The questionnaire for health care professionals was completed by the health care professionals after observing the consumption state of the subject. Diarrhea, abdominal distension, nausea, vomiting, and abdominal pain were investigated as digestive symptoms.

Before implementation of the survey, the appropriateness of the conduct was reviewed by the institutional review board of each facility and approved. Written informed consent was obtained from each patient or a proxy consenter.

Evaluation items

The evaluation items were the consumption rate and amounts of intake of energy, protein, lipids, carbohydrate, and sodium, as well as the satisfaction level evaluated by the responses to the questionnaires provided by the participants and their health care professionals.

Evaluation method

For the consumption rate and dietary nutrition intake, the mean scores for 3 d of study diet ingestion and 4 d of modified traditional diet ingestion and the

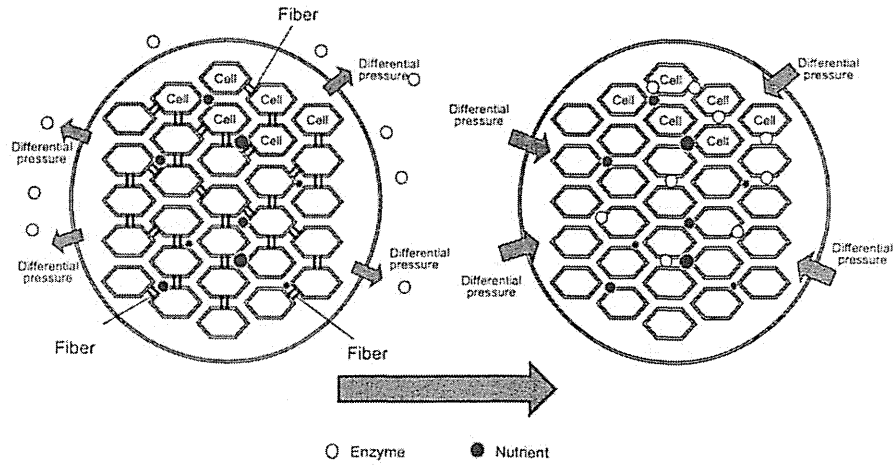


Fig. 2. Enzyme homogeneous permeation.

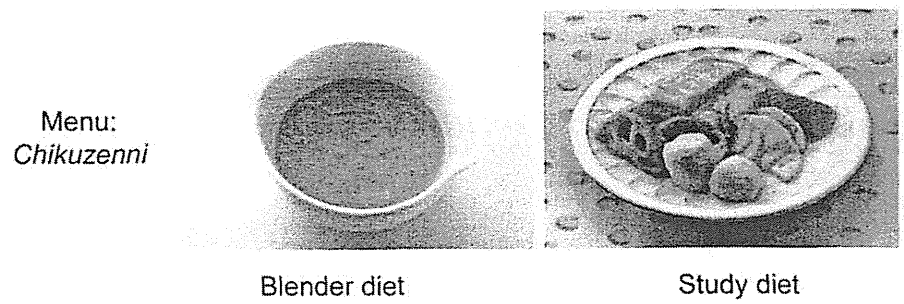


Fig. 3. Comparison of the appearances of the blender diet and the study diet.

daily results were compared. The results of the questionnaires were evaluated by six-stage grading and the mean values were calculated. The means of three meals during the 3-d study diet period and the 4-d modified traditional diet period were compared.

Statistical analysis

The per-protocol population was the major analysis population. A paired *t* test was performed for the consumption rate and amounts of intake of energy, protein, lipids, carbohydrate, and sodium between the modified traditional diet and the study diet (level of significance, $P < 0.05$; two-sided). Wilcoxon's signed rank-sum test was performed for the results of the questionnaires (level of significance, $P < 0.05$; two-sided).

Results

Handling of cases

Of the 72 participants registered, 57 were included in the final analysis after excluding 1 participant for violation of a served meal, 8 participants who dropped out, and 6 participants who had disease-induced fever or poor oral ingestion associated with anticancer agents.

Patient demographic factors

Table 4 shows the demographic factors of the 57 participants included in the study. Body mass index (BMI) was within the standard range, but close to the lower limit at 18.5 kg/m^2. The relatively low BMI was considered to reflect the nutrition state of the participants who were served meals for patients with impaired mastication, for which the consumption rate was <75%. The demographic data revealed that the underlying diseases of the participants were varied, and that meals for patients with impaired mastication were served to patients with various underlying diseases, rather than to patients with specific disease types. There were no established names for the meals served at the facilities, and various names were used at each facility (Table 5).

Table 1
Comparison of the hardness values of the study diet and a common meal

Menu	Ingredient	Hardness* (×104 N/m^2)	
		Common meal	iEat
Chikuzenni	Carrot	9.1 ± 1.3	0.4 ± 0.2
	Chicken breast	69.0 ± 1.6	1.2 ± 0.3
	Bamboo shoot	107.5 ± 17.0	0.2 ± 0.0
	Burdock	39.1 ± 5.4	0.3 ± 0.1
	Lotus root	80.5 ± 9.0	1.0 ± 0.1

* The hardness was measured at 45°C, as the presumed heating temperature before eating.

Consumption rate

Tabulation and analyses were performed for 55 participants after excluding 2 additional participants who were served a modified traditional diet of porridge or thick porridge during the study diet period instead of the study diet rice (iEat® rice).

No significant differences were observed between the study diet and the modified traditional diet for both the mean consumption rates and daily consumption rates (Fig. 4).

Dietary nutrition intake

Tabulation and analyses were performed for 54 participants after excluding another participant for whom information on nutrients of the modified traditional diet was unknown.

The mean energy intake (EI) and mean protein intake were significantly higher during the 3-d study diet period than during the 4-d modified traditional diet period. In a comparison of day 2 and day 3, when the modified traditional diet was switched to the study diet, the amounts of EI, protein and lipid intake were significantly higher on day 3. On the contrary, in a comparison of day 5 and day 6, when the study diet was switched back to the modified traditional diet, the amount of intake of protein was significantly higher on day 5 (Table 6).

Questionnaire

The mean satisfaction levels during the total ingestion period of the study diet and modified traditional diet were evaluated by the participants and their health care professionals. The study diet had significantly higher scores than the modified traditional diet for "appearance" when evaluated by the participants, and for "joy of eating" and "overall satisfaction level" when evaluated by the health care professionals (Fig. 5). No significant difference was observed between the modified traditional diet and the study diet for ease of meal assistance when evaluated by the health care professionals for 38 participants who required total or partial assistance with consumption.

Gastrointestinal symptoms

Six occurrences of gastrointestinal (GI) symptoms (two of abdominal pain, one of vomiting, two of nausea, and one of abdominal distension) were reported in four participants, but all of these occurrences were judged to be unrelated to the study diet.

Table 2
Nutrients of the study diet

Menu			Weight (g)	Calories (kcal)	Protein (g)	Lipids (g)	Carbohydrate (g)	Sodium (mg)
Day 3	Breakfast	Rice	183	200	3.1	0.7	45.4	38
		Broiled salmon	62	122	11.8	7.7	0.2	122
		Chikuzenni	156	85	6.5	0.3	13.1	479
		Breakfast total	401	407	21.4	8.7	58.7	639
	Lunch	Rice	183	200	3.1	0.7	45.4	38
		Chicken teriyaki	86	89	10.7	1.7	7.2	235
		Creamed pork and beans	115	123	11.3	5.5	7.1	252
		Lunch total	384	412	25.1	8.0	59.7	525
	Dinner	Rice	183	200	3.1	0.7	45.4	38
		Braised sablefish	77	151	8.1	10.5	4.6	255
		Pot-au-feu	155	110	4.5	8.0	5.6	624
		Apple	102	91	0.0	0.0	22.9	24
		Dinner total	517	552	15.7	19.2	78.5	941
	Total		1302	1371	62.2	35.9	196.9	2105
Day 4	Breakfast	Rice	183	200	3.1	0.7	45.4	38
		Yellowtail teriyaki	90	164	10.4	8.0	10.9	292
		Nikujaga	166	119	5.8	2.6	17.9	393
		Breakfast total	439	483	19.3	11.3	74.2	723
	Lunch	Rice	183	200	3.1	0.7	45.4	38
		Marinated pork	93	112	10.4	4.8	5.6	235
		Braised pumpkin and beans	91	102	12.3	2.7	6.5	239
		Lunch total	367	413	25.8	8.1	57.4	512
	Dinner	Rice	183	200	3.1	0.7	45.4	38
		Sukiyaki	17	120	7.1	3.8	13.2	456
		Pan-fried red fish with oyster sauce	77	76	10.4	2.4	2.5	272
		White peach	102	103	0.3	0.0	25.9	30
		Dinner total	538	499	20.9	6.9	87.0	796
	Total		1343	1395	66.0	26.3	218.7	2031
Day 5	Breakfast	Rice	183	200	3.1	0.7	45.4	38
		Pan-fried shrimp and scallops with vegetables	100	61	10.8	0.5	3.2	287
		Grilled mackerel	62	196	10.3	16.1	0.2	153
		Breakfast total	344	457	24.2	17.3	48.8	478
	Lunch	Rice	183	200	3.1	0.7	45.4	38
		Beef stir-fried with black pepper	101	118	10.8	6.0	4.5	310
		Chinese-style boiled vegetables	131	61	4.5	0.8	10.0	299
		Lunch total	415	379	18.4	7.5	59.9	647
	Dinner	Rice	183	200	3.1	0.7	45.4	38
		Chicken curry	110	91	10.9	1.2	8.7	249
		Scallops and cauliflower in sticky sauce	170	67	7.3	0.5	9.0	548
		Mango	115	135	0.3	0.0	33.6	29
		Dinner total	578	493	21.6	2.4	96.7	864
	Total		1337	1329	64.1	27.1	205.4	1989

Table 3
Study sites and investigators

Study site	Investigator
Sapporo Minami Seishu Hospital	Nobuhisa Nakajima
General Rehabilitation Mihono Hospital	Hirofumi Nishiyama
Minamiyamato Hospital	Shin Fujii
Hokuto City Koyo Hospital	Hajime Nakase
Kanazawa Nishi Hospital	Tsutomu Kikuchi
Hirano General Hospital	Makoto Shimazaki
Chita City Hospital	Naoharu Mori
Fujita Health University Nanakuri Sanatorium	Akihiro Ito
Owase General Hospital	Hiroyuki Kato
Tsu Seikyo Hospital	Tomonori Miyazaki
Japanese Red Cross Kyoto Daiichi Hospital	Fumiko Oshima
Wakakusa Daiichi Hospital	Hideharu Yamanaka
Wakakusa Tatsuma Rehabilitation Hospital	Masataka Itoda
Kaneda Hospital	Takuji Mimura
Sunami Shusaikai Hospital	Yukitsugu Arimoto
Shinbeppu Hospital	Nobuyuki Kikuchi
Kumamoto Daiichi Hospital	Tetsushi Nogami

Discussion

Study diet: iEat®

Either minced diets or blender diets usually are served to patients having difficulty with mastication because of aging or disease, to suit the individual conditions. Yamashita et al. [13] pointed out that the amounts of nutrients supplied in minced and blender diets were reduced by the cooking process, because of the addition of water to soften the food or removal of components that were difficult to eat. Other problems considered to be inherent with blender diets and minced diets are that the addition of water and process of mincing increases the portion size and prevents sufficient nutritional intake, respectively, resulting in an undernutrition state. It is also a problem that the appearance of foods cannot be retained after softening by these methods [14]. In Japan, attempts have been made to solve the problem of appearance by adding a thickener to blender diets to reconstitute to the original appearance of the ingredients, but this requires a human touch. Techniques for softening foods by

Table 4
Demographic factors

	n	%
Sex		
M	23	40.4
F	34	59.6
Meal assistance		
None	34	59.6
Total	17	29.8
Partial	6	10.5
Dentures		
Yes	30	52.6
No	27	47.4
	Mean	SD
Age (y)		
M	78.5	±8.8
F	83.7	±9.0
Total	81.6	±9.3
Height (cm)		
M	158.9	±6.9
F	143.6	±8.0
Total	149.8	±10.6
Weight (kg)		
M	47.8	±9.2
F	38.7	±7.8
Total	42.3	±9.4
BMI		
M	19.0	±3.6
F	18.7	±3.3
Total	18.8	±3.4
BEE		
M	988.0	±172.4
F	899.0	±105.3
Total	934.9	±140.7
Underlying disease	n	%
Stroke (including sequelae)	19	33.3
Cancer/malignant neoplasm (including postsurgery)	9	15.8
Heart failure/heart disease	7	12.3
Fracture	5	8.8
Dehydration	4	7.0
Pressure ulcers	3	5.3
Pneumonia	2	3.5
Anemia	2	3.5
COPD	2	3.5
Dementia	2	3.5
Diabetes	1	1.8
Parkinson's disease	1	1.8
Other	17	29.8
None	2	3.5

BEE, basal energy expenditure; BMI, body mass index; COPD, chronic obstructive pulmonary disease

Table 5
Types of main and side dishes

Type of main dish	n	%
Porridge	40	70.2
Soft rice	10	17.5
Rice	2	3.5
Thickened porridge	2	3.5
Blender porridge	2	3.5
Gelled porridge	1	1.8
Total	57	100
Type of side dish	n	%
Minced diet	32	56.1
Blender diet	6	10.5
Bite-sized food	6	10.5
S-1 diet*	5	8.8
Soft food	3	5.3
Soft dish	3	5.3
Pressure-cooked diet or food	1	1.8
Stewed food	1	1.8
Total	57	100

* S-1 diet is an intermediate between a blender diet and a very finely minced diet, comprising a meal of a very finely minced diet in thick sauce.

infusing hydrolytic enzymes, such as proteases and cellulases, recently have been reported [15,16]. These techniques make it possible to serve softened foods without changing the original appearances, which cannot be achieved using ordinary cooking methods.

The study diet evaluated here was developed using an enzyme-infusion method [17] that evenly infuses the enzyme within the ingredients to adjust the entire meal to a homogeneous softness. Because the study diet does not require the addition of water for softening, the nutrients are not diluted and the serving portion is not increased. As shown in Figure 3, the mean weight of food intake for the study diet was lower than that for the modified traditional diet. However, the study diet showed significantly higher levels of mean EI and protein intake than the modified traditional diet. The dietary nutrition intake per weight was higher for the study diet than for the modified traditional diet, and the study diet was an efficient diet rich in nutrients in a smaller quantity of food. Olin et al. [18] also reported that serving a high-density meal is more cost-effective for improving spontaneous EI by the elderly, and the study diet evaluated here would be positioned as a meal with such characteristics.

Consumption rate

No significant difference in the consumption rates was observed between the study diet and the modified traditional diet in this study. Few reports have been published about the effects of the appearance of a meal on the amount of food intake. Listed as factors related to food intake are tastiness of a meal, number of people present, food accessibility, eating locations, food color, ambient temperature and lighting, temperature of food, smell of food, time of consumption, and ambient sounds [19]. The relationships among the people sharing a meal are especially important, and it is generally reported that the amount of dietary intake is increased when more people are present. A mealtime becomes more relaxed and longer when eating with family or friends than when eating with strangers, which consequently results in increased amounts of dietary intake [19]. Li et al. also reported that age, sex, educational attainment, community, activity level, marital status, and drinking were significantly associated with fruit and vegetable consumption [20]. The results of the present study suggest that not only the appearance of food, but also other ambient factors, should be improved to increase the consumption rate. Lifestyle factors may need to be considered when dietary pattern is evaluated [21].

Although it is widely known that the results for consumption rates differ considerably depending on the survey methods used [22], the weight differential method used in the present study is considered to be the most accurate among the various methods [3,23].

Dietary nutrition intake

In addition to the intake of an appropriate amount of energy, intake of an appropriate amount of protein is

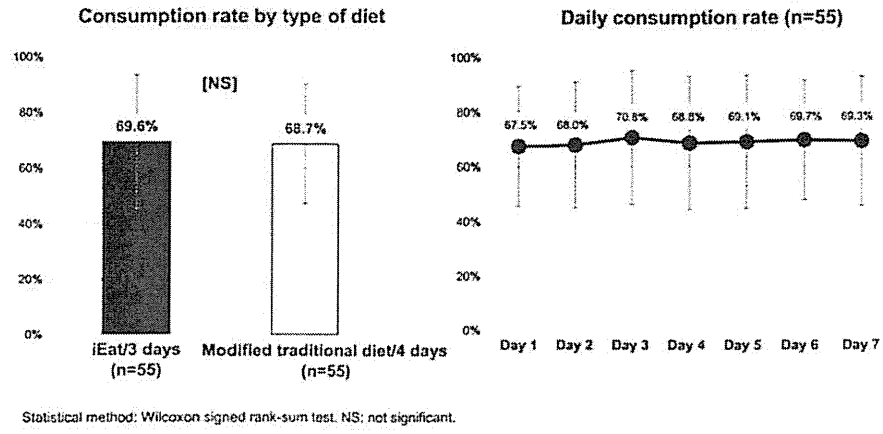


Fig. 4. Results of the consumption rate survey. Days 1, 2, 6, and 7: modified traditional diet; days 3–5: study diet.

indispensable for improvement and maintenance of the nutritional condition, and the requirement does not decrease in the elderly [24]. As reported previously, the mean EI and protein intake were significantly higher for the study diet than for the modified traditional diet. The significantly lower weight of food intake with the study diet compared with the modified traditional diet means a higher dietary nutrition intake per weight for the study diet compared with the modified traditional diet. Tanaka et al. [25] reported that the amount of protein intake from meat becomes lower with aging, and that a reduction in the intake of meat with favorable digestibility was the cause of lowered serum albumin. In the study diet, the foods are made sufficiently soft to be mashed by the tongue, even for meats that are difficult to soften by ordinary cooking methods, and this physical property would be one of the factors for the significantly higher level of protein intake in this study. The present results for the study diet suggest the possibility of improving the decreased protein intake associated with aging.

Survey of satisfaction level

With respect to the satisfaction level evaluated by the participants, the study diet scored significantly higher than the modified traditional diet for "appearance" based on the mean scores of the modified traditional diet (4 d) and the study diet (3 d). The effect of a difference in the appearance of a meal on the satisfaction level was evaluated by the participants. "Eating" is important for the elderly in terms of joy and purpose, and mealtimes were reported to be the number one joy for elderly people admitted (institutionalized) to nursing care facilities [26]. The joy of meals is expected to be enhanced by giving thought to the appearance of the meals.

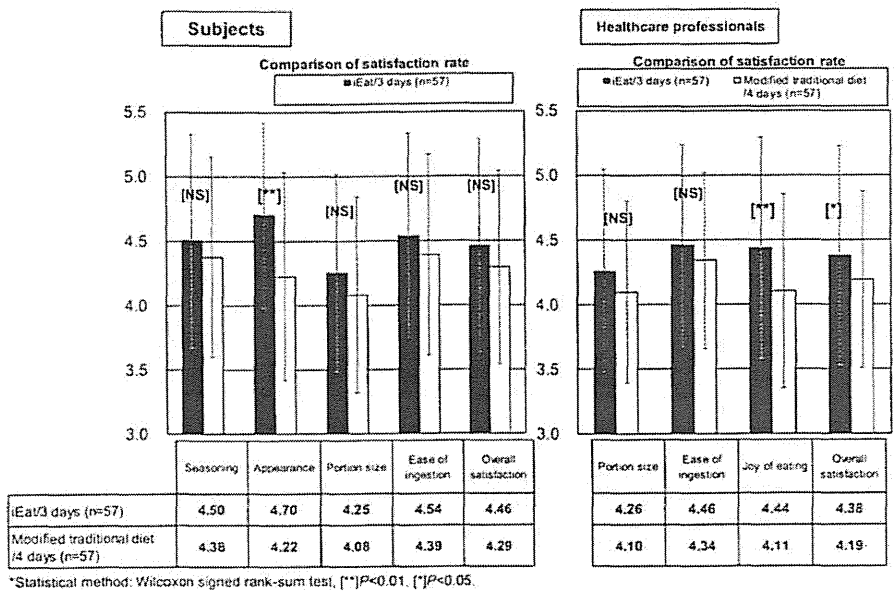
Based on the evaluation by the health care professionals, the mean scores of "joy of eating" and "overall satisfaction level" were significantly higher for the study diet than for the modified traditional diet. It was shown that a change in the appearance of a meal influenced the joy of eating and the satisfaction level of the participants as evaluated by the health care professionals.

Table 6
Intake of nutrients

Consumption rate by type of diet: weight of ingested diet/amount of nutrients ingested					
	iEat (3 d)			Modified traditional diet (4 d)	
	Mean		± SD	Mean	± SD
Energy (kcal)	[*]	1097.2	±395.0	1036.4	±349.3
Protein (g)	[**]	49.9	±18.1	40.0	±14.1
Lipids (g)	[NS]	25.2	±9.8	25.3	±10.8
Carbohydrate (g)	[NS]	166.7	±61.6	161.4	±54.9
Sodium (mg)	[NS]	2302.4	±873.9	2261.8	±989.5
Total weight (g)	[**]	1099.2	±406.8	1222.7	±420.6

Daily consumption rate: weight of ingested diet/amount of nutrients ingested								
	Modified traditional diet		iEat				Modified traditional diet	
	Day 1	Day 2	Day 3		Day 4	Day 5	Day 6	Day 7
Energy (kcal)	1032.0	1032.2	[**]	1128.0	1104.6	[NS] 1059.1	1032.3	1049.3
Protein (g)	39.2	40.6	[**]	49.8	50.6	[**] 49.3	39.6	40.8
Lipids (g)	23.7	25.5	[**]	30.0	22.7	[NS] 22.9	25.3	26.6
Carbohydrate (g)	168.1	156.4	[NS]	163.9	172.3	[NS] 163.8	163.9	157.2
Sodium (mg)	2315.7	2214.3	[NS]	2338.0	2353.4	[NS] 2215.8	2218.6	2298.5
Total weight (g)	1207.2	1208.1	[**]	1092.5	1114.3	[**] 1090.7	1269.4	1209.7

Statistical method: *t* test. [**] $P < 0.01$, [*] $P < 0.05$.



*Statistical method: Wilcoxon signed rank-sum test. [**]$P<0.01$, [*]$P<0.05$.

Fig. 5. Comparison of satisfaction rates based on the questionnaire.

These findings clarified the significance of meals for not only supplementing nutrients, but also satisfying the participants.

Conclusions

The present results suggest that the study diet may have potential to replace modified traditional meals, such as minced diets and blender diets, for patients with impaired mastication, because it improved the satisfaction level for meals of patients who cannot eat ordinary meals, and increased EI and protein intake.

Acknowledgments

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