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Muscle Hypertrophy and Resistance Training: Efficacy of Nutritional Supplementation

by Kevin Tipton

The key for skeletal muscle growth lies in the relationship of muscle protein synthesis to muscle protein breakdown. Muscle hypertrophy occurs only from net muscle protein synthesis, ie, when muscle protein synthesis exceeds breakdown. Clearly, progressive resistance weight training results in muscle growth.

The major stimulus for muscle hypertrophy is the nature and frequency of the weight training combined with normal meal consumption. Although many claims have been made, it is presently unknown whether additional muscle growth is stimulated by supplement intake and what is the best strategy to optimize stimulation of muscle growth. Long-term performance endpoint (eg, increased muscle mass or strength) studies of supplements are nearly impossible to control properly and may not be feasible. Any effect of supplementation in addition to that of normal meal intake will be secondary and thus will be more difficult to detect chronically.

Consequently, to get a measurable result, an endpoint study of training plus supplementation would need strict control of diet, exercise, and other lifestyle variables over a long duration. Alternatively, the muscle mass gains from the addition of the

supplements, although difficult to detect, may be physiologically important. The main focus of this review is to examine the response of muscle protein metabolism to resistance exercise and nutrient intake in acute situations in an attempt to shed light on the efficacy of supplement intake to stimulate additional muscle growth.

One suggested rationale for stimula-

Taking a nutritional supplement during training could lead to muscle growth by contributing to increased positive net muscle protein balance.

tion of muscle growth through nutritional supplementation is to simply add protein to a normal diet. However, increased protein intake does not increase net muscle protein balance,¹ and thus increasing protein intake to maximize muscle growth has generally been discounted.^{2,3} However, taking a nutritional supplement during training could lead to muscle growth by con-



CPE article: Nutrition and Aging in Okinawa: Is There a Diet that Extends Health Span?

by Bradley Willcox, MD, MS, D Craig Willcox, MA, PhD (cand), and M Suzuki, MD, DMedSc

Learning Objectives

After you read this article, you will be able to:

- Describe the supportive evidence for how the Okinawan diet expands health span.
- List the basic dietary habits of the Okinawans, the macronutrient proportions of the Okinawan diet, and the micronutrients and phytochemicals that are abundant in the diet.
- Describe the health benefits that have been linked to the Okinawan dietary approach.

The study of diet and longevity is controversial, though hardly new. In the 3rd century BC the Chinese had already devised dietary principles for longevity through Taoist teachings outlined in *The Yellow Emperor's Classic of Internal Medicine*, which advocated the limitation of diet to achieve maximal longevity.¹

While we have no documented evidence of the success of the Taoist dietary prescription for the ancient Chinese, we do have evidence for the Okinawans. These inhabitants of a Japanese archipelago that stretches 800 miles across the East China Sea (between the main islands and Japan and Taiwan) may have borrowed a page from ancient text to reap impressive health and life expectancy benefits.

The Science Behind the Okinawan Diet

In the 1930s, 23 centuries after the Taoist longevity prescription, experiments by Clive McKay at Cornell University confirmed that caloric restriction in rodents extends life expectancy by up to 50%, the equivalent of 150 to 160 years of life in humans.² The most plausible theoretical

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mechanism is thought to be a reduction in production of cell-damaging oxygen radicals that are generated primarily by metabolizing food for energy.³

Eating less generates fewer free radicals, thus minimizing potential damage to cellular machinery, such as DNA or mitochondria. This ultimately should result in slower aging at the cellular level. Few biomarkers exist to verify that this actually slows the aging process, but among the most promising may be DHEA levels, which seem to decline in a straight line with age.⁴

McKay's caloric restriction experiments have now been repeated across many species with similar results.⁵ The results showed that not only did all species live longer but they were functionally younger. Animals' fur retained its sheen, age-related loss of calcium from bones was slowed, mice could run mazes at a clip equal to those half their age, and even simple rotifers lived longer—all through dietary manipulation. But can these findings be translated to higher species, including humans?

Current studies with primates at the National Institute on Aging show the same early adaptations in primates on low-calorie diets that were seen for the other species. These changes included slower age-related declines in plasma DHEA levels, lower fasting glucose levels, lower insulin levels, and reduced diabetes risk.⁴

If the usual rules of biology and physiology hold across species, and in this case they almost certainly do, then the primates on the low-calorie diet will outlive their well-fed counterparts

and do so in far better health. The Okinawans, according to caloric restriction experts, are the closest example of a human population that eats such a diet.⁶

Extremely Long-Lived Humans—Fact or Fiction?

Are there other human examples of this phenomenon? Perhaps—but researchers have not yet found them. The identification of long-lived populations has been hampered by the lack of reliable age verification data, which lends itself to age exaggeration and false conclusions.

A good example is the supposed identification of extremely long-lived populations in the Caucasus mountains of the old Soviet Union, the Hunza Valley in Pakistan, and the village of Vilcabamba in Ecuador. Ages as great as 168 years were reported, and foods that they ate, such as yogurt, were touted as panaceas for the aging process.⁶ Close inspection by Western gerontologists identified few centenarians and found life expectancy to be lower in all areas than in the US.^{7,8}

Okinawa's Evidence-based Extreme Longevity

Because Okinawa is a prefecture (state) of Japan, all Okinawans are registered in a koseki (family registry) that possesses reliable age verification data.¹⁰ The koseki system dates back 120 years, so age validation is possible for all citizens. Moreover, the Japanese are known for reliable health statistics, and as of 1995, these data showed that Okinawans have the longest docu-



mented life expectancy for any country or state, with life expectancy of 85.1 years for women and 77.2 years for men. Okinawans also possess what may be the highest concentration of centenarians ever reliably documented—about 35/100,000²¹ versus about 5 to 10/100,000²² in the US.

Many Okinawans are remarkably healthy. Approximately one third are independent with activities of daily living (ADLs) and another third require minimal to moderate assistance with ADLs.¹³ It is unlikely that this is all due to genetics, since there are large populations of Okinawan emigrants in Brazil and the US who suffer similarly high coronary heart disease and cancer rates as the local population and have similar, comparatively short life expectancies.¹⁴ Moreover, while genetics studies have revealed some protective genetic endowments for the longest-lived of the Okinawans, such as "healthier" human leukocyte antigen (HLA) patterns for centenarians, even those with less desirable patterns made it to the century mark.¹⁵

Adding Healthy Years

Okinawans also seem to be much healthier than their Japanese cousins, who, in turn, are much healthier than Americans. Recent data from the World Health Organization show that Japan exceeds all other countries both in terms of life expectancy and healthy years, as measured by disability-adjusted life years.¹⁶ A person born in Japan can expect to live an impressive six years longer, in good health, than a person born in the US.

Even more fascinating are the large differences within Japan itself in terms of life and health expectancy. Among all Japanese, Okinawans are the longest-lived and the least likely to get cardiovascular disease or a host of cancers, including breast and prostate. Furthermore, Okinawans do not have the high rates of stroke and stomach cancer seen in mainland Japanese.¹⁷ They are also the most functionally independent at older ages, despite their position at the bottom rung of the

Japanese socioeconomic ladder.^{17,18}

Does diet play a role in the Okinawan health phenomenon? We think it does. After 25 years of studying the island's centenarians, some clues are surfacing about their dietary habits that are consistent with what reputable nutrition authorities have been telling us all along: A low-calorie, low-fat, plant-based, complex carbohydrate-rich diet is the dietary key to maximizing life expectancy and minimizing risk for the debilitating diseases of aging.^{19,20}

As health professionals, we are living in interesting times. Nutrition recommendations are a moving target: low fat versus the right fat, low protein versus high protein, low carbohydrate versus high carbohydrate. The public, more confused than ever, is easy prey for the likes of ketogenic low-carbohydrate diets such as the Atkins²¹ or Protein Power diets.²² Others are trying to live in a mythical Zone created by Barry Sears where insulin is the enemy, glucagon the friend, and eicosanoids the key to separating friend from foe.²³ The public confusion is understandable, since so many different health and medical organizations offer different dietary advice.

Healthy and Unhealthy Eating Patterns

The recent creation of the Unified Dietary Guidelines¹⁹ by the National Cancer Institute, American Heart Association, American Dietetic Association, and National Institutes of Health suggests six simple rules for healthy eating to help simplify the plethora of dietary advice today. The rules emphasize a varied, plant-based diet high in carbohydrates (>55% of total calories), low in fat (<30% of total calories) and emphasizing monounsaturated or polyunsaturated fat in that order, 5 to 6 daily servings each of grains and vegetables/fruits, and no more than 6 g/day of salt. These guidelines might well be called the Okinawan dietary guidelines because of their remarkable similarity to what the Okinawans are already eating.^{24,25}

The Unified Dietary Guidelines are a

welcome contrast to the claims by various popular diet book authors about the Okinawans and their diet. For example, Barry Sears implies in his latest book, *The Soy Zone*, that Okinawans follow a Zone-like diet low in carbohydrate (40% of total calories) and high in protein (30% of total calories).²⁶ But this is untrue. Okinawans eat a diet low to moderate in protein (19% of total calories) and high in carbohydrate (55% to 60% of total calories).²⁵ Bob Arnot, NBC's health correspondent, stated that "everyone (in Okinawa) remains lean and taut."²⁷ Again, this is incorrect. The elder Okinawans, who eat a more traditional diet similar to the Unified Dietary Guidelines, are lean, with an average body mass index (BMI) of 21, but the younger Okinawans, who eat a more Westernized version similar to the current American diet, have the highest BMI of all Japanese (BMI: 26).²⁸ So what are the Okinawan elders eating to live so long and stay so healthy?

The Okinawan Diet

The following characterizes the Okinawan diet:

Basic habits:

- Calorie control (called "hara hachi bu" in Okinawa). This means stop eating when you are 80% full. This idea fits well with our knowledge of the physiology of digestion, in which the stomach stretch receptors take about 20 minutes to tell us we are full after a meal. If we stop at 80% we will likely be satisfied 20 minutes later when the stretch receptors kick in. This idea is ingrained in the traditional food culture, and has resulted in caloric intakes 10% to 40% lower than in the US.
- Portion control. Serving sizes are about half of those in the US, making Okinawans less likely to overeat.

Macronutrients:

- High carbohydrate intake (55%-60% of calories), emphasizing complex, low glycemic index vegetables and grains.
- Moderate protein intake (19% of calories), emphasizing vegetable protein, mostly from legumes, eg, soy

products such as tofu and miso soup).

- Low fat intake (26% of calories: 14% monounsaturated, 5% polyunsaturated, and 7% saturated).

Micronutrients/Phytochemicals:

- Rich in vitamins and minerals, including calcium (tofu, seaweeds, limited meats and dairy) and vitamin D (fish, mushrooms, and sunshine), high vitamin E intake (vitamin E-rich cooking oils and foods, resulting in 30% higher plasma vitamin E levels than Americans).^{29,30}
- Rich in phytochemicals, eg, very high dietary flavonoid intake (soy foods, onions, tea), such that Japanese have plasma flavonoid levels up to 40 times those of Caucasians,³¹ among the highest lycopene intake in Japan (watermelon, red-purple sweet potatoes).³²

Particular Foods:

- High vegetable/fruit consumption (six servings of vegetables/one fruit per day versus an average of three or four in the US).
- An emphasis on fish rather than red meat, thus providing a healthy dose of omega 3 fat, which may help protect against certain cancers and autoimmune diseases (omega 6:3 ratio of approximately 4:1).^{33,34}
- The highest soy intake in Japan, which has been linked to lower rates of coronary heart disease and cancer (especially hormone-dependent cancers).³⁵
- Healthy oils: canola/soy oil blend used for cooking, which is rich in monounsaturated fat and also provides omega-3 fat.
- Jasmine tea as the main beverage, which provides a high intake of polyphenols of the catechin class.
- Moderate alcohol consumption.
- Limited meat and dairy products (slightly higher than the rest of the Japanese, providing extra calcium and vitamin B¹² but still less than half of the meat and dairy intake in the US).
- Low salt intake (about 7 g/day compared with 12 g/day consumed by other Japanese), which plays a role in the low rates of hypertension, stroke,

and stomach cancer in the Okinawans relative to other Japanese.^{36,37}

- Frequent use of antioxidant/flavonoid rich herbs in cooking.³⁸

The health benefits that have been linked to the Okinawa dietary approach are impressive, as follows:

- Low homocysteine levels, low cholesterol levels, and minimal arteriosclerosis.^{39,40}
- Mortality from coronary heart disease approximately 80% lower than that of Americans.⁴¹
- Lower stroke mortality than Americans.⁴¹
- Breast cancer and prostate cancer approximately 80% lower than Americans.⁴¹
- Other cancers, including colon, ovarian, and lymphoma, more than 50% lower than Americans.⁴¹
- Hip fracture rates 50% lower than Americans.⁴²
- Dementia rates perhaps 30% to 40% lower than similarly-aged Americans.⁴³
- Increased functional capacity at older ages versus Americans.¹⁶

Conclusion

Is the Okinawan diet responsible for the impressive life and health expectancy of the Okinawans? If the dietary principles are applied to other populations will they also experience the same benefits? Will the Okinawan diet slow the aging process? Interventional studies in humans would take a century to answer these questions, but interventional studies in animals are supportive, as are epidemiologic, case-control, and cohort studies of the basic principles of the diet.

Moreover, the diet certainly seems to work in the Okinawans. Life expectancy is longer, the diseases of aging (including cancer and cardiovascular disease) occur with less frequency, and markers of biological age (such as DHEA levels) seem to be higher in Okinawans than age-matched Americans, possibly reflecting a younger biological age.^{44,45} Most impor-

tant, the added years are largely healthy ones.

More research is needed, especially cross-cultural studies using culturally sensitive research tools, to clarify what the contribution of other health behaviors might be to successful aging of the Okinawans. These are particularly important with regard to health care, social support, health attitudes, and spirituality, where women play the dominant role in Okinawan religion. In the final analysis, it is comforting that the world's longest-lived and healthiest people are eating what respected dietary authorities in the US are now recommending. It seems that the Taoists may have been right all along. ■

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