The musculoskeletal disease proneness profile

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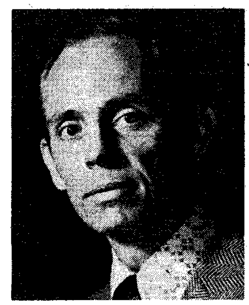

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The musculoskeletal syndrome is one of the large chronic disease problems in civilized society. Hence, it is imperative to develop practical preventive measures. To do this, it is essential to identify all possible risk factors. The evidence in this report suggests the possibility of many dietary factors operating in the genesis of musculoskeletal disease. The findings in this experiment are not all sharply defined, partly because of the techniques employed. Notwithstanding, there appear to be numerous resistance agents which discourage disease and a few susceptibility factors which invite disease. Incidentally, the findings in this report support earlier observations with regard to a mental illness proneness profile[2], an oral disease proneness profile[3], and a syndrome of sickness profile.[4]

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Introduction

Five interdependent points serve as the justification for and the prelude to this report.

First, the evidence is abundantly clear that musculoskeletal disease is one of the biggest problems in the United States today. In fact, according to data from the National Health Survey[1], 25,423,000 Americans reported one or more musculoskeletal problems in one record year. Second, the therapeutic armamentaria presently employed for musculoskeletal problems include few chemical agents other than those designed for symptomatic care. Third, the fundamental problems in the musculoskeletal syndrome are not particularly different than those encountered in other areas. For example, coronary artery disease is also recognized to be of epidemic proportions. Additionally, it is now granted that the present therapeutic approach can never resolve the problem. Thus, there is increasing interest in **primary** prevention, meaning **prevention of occurrence.** Because of such preventive concern, there is now available a **coronary proneness profile** of considerable effectiveness. It would be highly desirable to develop a like profile for the musculoskeletal problem. Fourth, there is now an increasing interest in orthomolecular therapy. Finally, the prevention of musculoskeletal illness, like the prevention of disease in any other part of the body, hinges upon the (1) **identification** and the subsequent (2) **elimination** of risk factors. There is no disagreement regarding these two strategic points. There is, on the other hand, considerable confusion as to what constitutes a **risk factor.** In order to resolve this point, it is first necessary to outline the course of events which eventuates in health or disease.

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The Anatomy of Health and Disease

In one sense, man may be viewed as a multilamellated sphere (Figure 1) which looks the same when viewed from any peripheral point. Likewise, peripherally, any way one turns man, the picture is the same.

What one encounters peripherally is a layer characterized by **signs** of disease. Here, one may observe a gangrenous leg, pimples on the skin, or a mobile tooth. All of these findings have in common the fact that they are signs of disease and represent the end result of a long incubation period.

If one peels off this most peripheral layer, a **symptom zone** comes into focus. These are findings which can only be elicited from the subject. In other words, they cannot be observed by the examiner directly. In this category one would include an itch, headache, or a toothache. What is particularly important is that symptoms generally **precede** signs of disease. Hence, in one sense of the word, symptoms may be viewed as risk factors since they forecast the advent of the more peripheral signs of disease.

By removing the second zone, the symptom layer, one brings into focus the **performance** area. On dissolving away this layer, the **biochemical** pattern is brought into view. Eliminating the biochemical layer brings into view the **hormonal** pattern. Beneath the hormonal layer is the **enzyme zone.** Finally, the core is represented by a series of problems which may rightly be classed as **lifestyle.** Surely, diet, or more correctly undernutrition or malnutrition, may be viewed as a critical risk factor since man is a food-dependent creature (Figure 1).

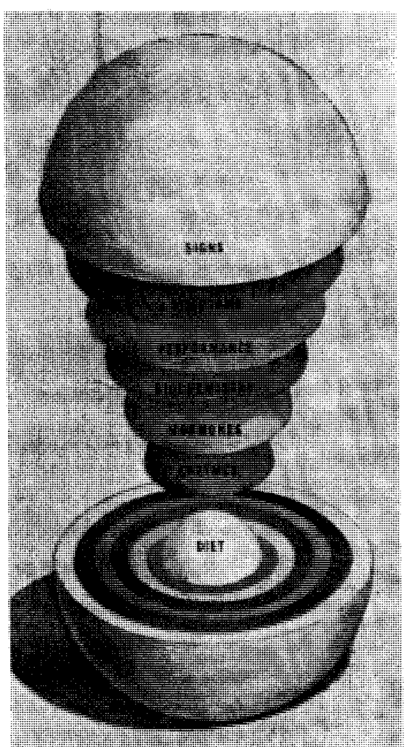

Figure 1. The sphere of man showing diet as the core problem.

It should be emphasized that there are many dietary as well as nondietary core factors. They may be categorized in two groups. Those factors which tend to discourage disease may be viewed as **resistance** factors or **pluses.** Conversely, those factors which encourage disease may be regarded as **susceptibility** factors or **minuses.**

Utilizing this experimental model, one can readily identify **primary** and **secondary** risk factors. For example, hypertension is a risk factor in the genesis of cardiovascular disease. Employing this experimental model, both hypertension and cardiovascular disease would be identified in the most peripheral zone with cardiovascular disease superficial to hypertension. However, hypertension can only be viewed as a **secondary** risk factor, since the next question which arises is what causes the hypertension. Hence, in the final analysis, the **true** or **primary** risk factors are the core problems. These include, in addition to diet, physical activity, light, tobacco, coffee/tea, alcohol, and many other known and likely unknown variables.

In this discussion, consideration will be given to the relationship of the peripheral layers as judged by **musculoskeletal** symptoms and signs versus the core as measured by **diet** and some other **nondietary** factors.

Method of Investigation

In 1965, a multiple testing health program for members of the health professions was inaugurated. This program has grown so that at the present time, 832 dental practitioners and their wives have been studied in terms of dietary patterns and musculoskeletal symptoms and signs.

The Cornell Medical Index Health Questionnaire is a list of 195 questions followed by two responses, yes and no. The subject is asked to choose the response he or she thinks is appropriate. If in doubt, the subject is asked to guess. The CMI has been devised as an instrument for quickly obtaining a descriptive sketch, for clinical interpretation, of a person's attitude, moods and feelings, emotions, and bodily reactions. One section consists of eight questions relating to the musculoskeletal system (Figure 2).

At each visit, each subject completed a food frequency questionnaire **and** a seven-day dietary record. The forms were submitted to a computer center and printouts became available outlining the daily intake of all the major foodstuffs as well as the most common vitamins and minerals.

Hence, with these data, it is possible to study the relationships between diet and the musculoskeletal syndrome.

Sessions were held periodically to discuss the health of the group; dietary deficiencies and excesses were pointed out and suggestions offered as to how to improve the diet. Also, discussions were conducted about the role of nondietary factors in musculoskeletal health and disease. Annually, the health questionnaires and the dietary surveys have been repeated. **Thus, it has been possible to compare changes in diet and other nondietary risk factors versus changes in musculoskeletal symptoms and signs.**

Results

Figure 3 is designed to study the relationship of musculoskeletal symptoms and signs (as derived from the Cornell Medical Index Health Questionnaire) versus the daily mean percentage of calories derived from refined carbohydrate foodstuffs (as judged from a food frequency questionnaire). Three points warrant particular mention. First, the mean daily percentage of calories derived from refined carbohydrate foodstuffs in the group with no musculoskeletal symptoms and signs is 18.4%; in contrast, the daily intake in those with 1+ musculoskeletal symptoms and signs is 21.5%. This is an approximate 17% difference in the two groups. Second, by definition, refined carbohydrate foodstuffs are to be viewed as a susceptibility agent since, when added, it tends to encourage disease. Third, the difference between the two groups is statistically highly significant ($t=3.440$, $P<0.001$).

And so it would appear that subjects with musculoskeletal symptoms and signs are more apt to be consuming relatively more refined carbohydrate foodstuffs than those free of such clinical findings.

Figure 4 is a summary of the relationship of the musculoskeletal scores in terms of all nutrients studied by the food frequency technique. The additional point should be made that the nutrients have been arranged in decreasing order of statistical importance as determined by the t value. Figure 4 deserves particular attention for four reasons. First, it is clear that the percentage of total calories derived from refined carbohydrate foodstuffs (line 1) is number one in order of statistical importance. Second, it will be noted that another measure of refined carbohydrate intake (calories derived from refined carbohydrates) also followed the same pattern (line 2). Specifically, those with no musculoskeletal symptoms and signs consume approximately 389 calories from refined carbohydrates; those with 1+ musculoskeletal findings 485 calories. This 25% difference is highly statistically significant ($t=3.365$, $P<0.005$). Third, Figure 4 also points out other statistically significant relationships including pantothenic acid (line 3), vitamin B_6 (line 4), vitamin B_{12} (line 5), vitamin E (line 6), vitamin A (line 7), vitamin B_1 (line 8), vitamin B_2 (line 9), and vitamin B_3 (line 10). The additional point should be made that these latter items must be viewed as resistance agents because the group characterized by no musculoskeletal findings shows a higher intake of each of these vitamins. This is in contrast to the refined carbohydrate determination which suggests that this nutrient must be viewed as a susceptibility factor. Fourth, while other nutrients do not quite satisfy the five percent confidence level (line 11 and below), they nevertheless follow a very logical pattern. For example, the total carbohydrate intake (line 11) is higher in those with musculoskeletal complaints than in those without. The vitamin C daily consumption

musculoskeletal symptoms and signs
(Cornell Medical Index Health Questionnaire)

Are your joints often painfully swollen?
Do your muscles and joints constantly feel stiff?
Do you usually have severe pains in the arms or legs?
Are you crippled with severe rheumatism (arthritis)?
Does rheumatism (arthritis) run in your family?
Do weak or painful feet make your life miserable?
Do pains in the back make it hard for you to keep up with your work?
Are you troubled with a serious bodily disability or deformity?

Figure 2. The eight musculoskeletal symptoms and signs utilized for the development of the musculoskeletal disease proneness profile.

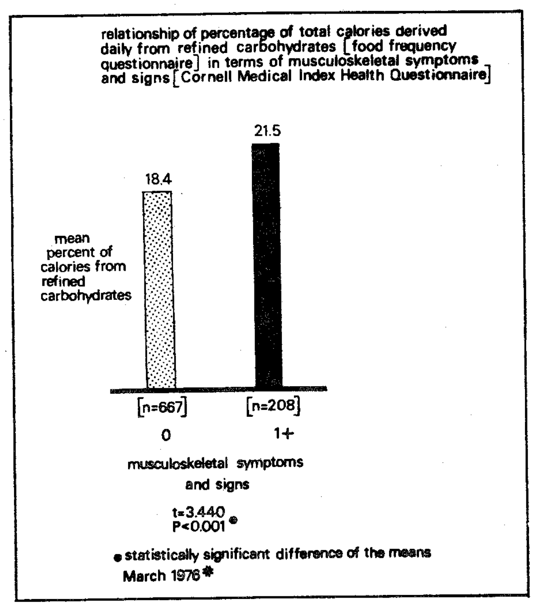

Figure 3. The relationship of the percentage of total calories derived from refined carbohydrate foodstuffs (as established from a food frequency questionnaire) versus the total number of musculoskeletal symptoms and signs (as judged from the Cornell Medical Index Health Questionnaire). The 208 subjects characterized by 1+ musculoskeletal findings report a statistically significantly higher intake of calories derived from refined carbohydrate foods.

(line 12) is less in those with 1+ musculoskeletal findings. The vitamin C pattern is duplicated with calcium, phosphorus, valine, isoleucine, phenylalanine, protein, lysine, tryptophan, and others.

In summary, it appears from this binomial analysis and utilizing a food frequency questionnaire, that a number of nutrients appear related to the musculoskeletal disease proneness profile. Sugar and other measures of refined carbohydrates appear as susceptibility factors; a number of vitamins, minerals, and amino acids must be viewed as resistance agents.

Because of the newness of this subject and the particular approach utilized, we thought it advisable to recheck our data by employing **correlation coefficients** instead of the **binomial analysis** described earlier.

For example, Figure 5 depicts the relationship of the daily vitamin E intake (as established from the food frequency questionnaire discussed earlier) versus the total number of musculoskeletal symptoms and signs (as judged from the Cornell Medical Index Health Questionnaire previously analyzed). Shown on the abscissa are musculoskeletal symptoms and signs depicted as 0, 1, 2, and 3+.

musculoskeletal disease proneness profile
as determined from the Cornell Medical
Index Health Questionnaire and a
food frequency questionnaire

	complaints 0	1+	% difference	t	P
1] percentage of total calories derived from refined carbohydrates	18.4	21.5	17	3.440	<0.001*
2] calories from refined carbohydrates	389	485	25	3.365	<0.005*
3] pantothenic acid (mgs)	18.0	16.0	11	3.206	<0.005*
4] vitamin B_6 (mgs)	4.7	4.2	12	3.166	<0.005*
5] vitamin B_{12} (mcgms)	13.3	11.1	16	3.137	<0.005*
6] vitamin E (IU)	80	66	18	3.063	<0.005*
7] vitamin A (USP units)	19591	17235	12	2.985	<0.005*
8] vitamin B_1 (mgs)	5.3	4.4	18	2.775	<0.010*
9] vitamin B_2 (mgs)	6.4	5.4	15	2.626	<0.010*
10] vitamin B_3 (niacin) (mgs)	71	59	17	2.601	<0.010*
11] total carbohydrate (gms)	180	197	9	1.959	>0.050
12] vitamin C (mgs)	334	313	6	1.662	>0.050
13] calcium (mgs)	1134	1063	6	1.644	>0.100
14] approximate refined carbohydrate intake (gms)	74	87	17	1.561	>0.100
15] phosphorus (mgs)	1591	1528	4	1.398	>0.100
16] approximate sugar per day (teaspoons)	18.4	20.4	11	1.376	>0.100
17] valine (mgs)	5474	5261	4	1.306	>0.100
18] isoleucine (mgs)	5316	5126	4	1.229	>0.200
19] phenylalanine (mgs)	4283	4141	3	1.216	>0.200
20] protein (gms)	104	101	3	1.062	>0.200
21] lysine (mgs)	7047	6827	3	1.035	>0.200
22] tryptophane (mgs)	1175	1143	3	0.995	>0.200
23] total calories per day	2020	2073	3	0.956	>0.200
24] threonine (mgs)	3885	3781	3	0.936	>0.200
25] iron (mgs)	32	30	7	0.932	>0.200
26] total sodium (mgs)	2815	2879	2	0.861	>0.200
27] iodine (mgs)	0.70	0.68	3	0.852	>0.200
28] leucine (mgs)	7654	7492	2	0.759	>0.400
29] methionine (mgs)	2273	2223	2	0.712	>0.400
30] polyunsaturated fatty acids	13.7	13.4	3	0.609	>0.500
31] ratio calcium/phosphorus	0.71	0.70	1	0.567	>0.500
32] fat (gms)	119	117	1	0.477	>0.500
33] percentage polyunsaturated to saturated fat	14.8	14.5	2	0.468	>0.500
34] potassium (gms)	2070	2018	3	0.388	>0.500
35] magnesium (mgs)	326	322	1	0.384	>0.500

*statistically significant difference of the means
March 1976#

Figure 4. The musculoskeletal disease proneness profile as determined from the Cornell Medical Index Health Questionnaire and a food frequency questionnaire. It is evident that there are a number of statistically significant relationships between various nutrients and the musculoskeletal profile.

Described on the ordinate is the mean daily vitamin E intake expressed in International Units. It is clear that those 792 subjects with no musculoskeletal symptoms and signs consumed the greatest daily intake of vitamin E (80.5 IU). Conversely, the 23 subjects with 3+ musculoskeletal symptoms and signs are consuming the least amount of daily vitamin E (54.0 IU). As a matter of fact, as the number of musculoskeletal findings rise (moving from left to right on the abscissa), the daily vitamin E intake (on the ordinate) declines. Finally, there is a statistically significant negative correlation (r= -0.094, P<0.01).

Hence, within the limits of this experiment, it would appear that subjects with musculoskeletal symptoms and signs are consuming relatively less vitamin E than those free of such clinical findings.

Figure 6 is a **summary** of the relationship of the musculoskeletal scores in terms of **all** nutrients studied by the food frequency questionnaire. Additionally, the point should be made that the nutrients have been arranged in decreasing order of statistical importance as determined by the correlation coefficient. Figure 6 deserves particular attention for four reasons. First, it is clear that the total carbohydrate intake (line 1) expressed in grams is number one in order of statistical importance. Since the correlation is positive, this suggests that the higher the total carbohydrate intake, the greater the number of musculoskeletal symptoms and signs.

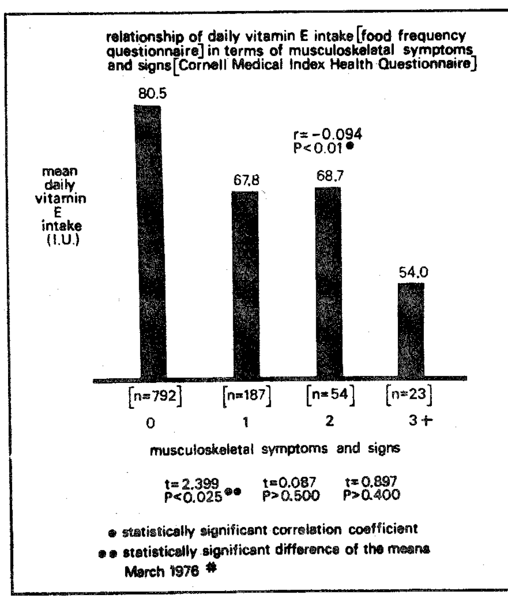

Figure 5. The relationship of the daily vitamin E intake (as established from a food frequency questionnaire) versus the total number of musculoskeletal symptoms and signs (as judged from the Cornell Medical Index Health Questionnaire). As the number of musculoskeletal findings rise (moving from left to right on the abscissa), the daily vitamin E intake (on the ordinate) declines. There is a statistically significant negative correlation (r = —0.094, P <0.01).

Second, it will be noted that other measures of refined carbohydrate intake, such as the approximate refined carbohydrate intake as expressed in grams (line 2), the calories derived from refined carbohydrates (line 3), the percentage of calories from refined carbohydrates (line 4), and the approximate sugar per day as shown in teaspoonsful (line 13), also follow the same pattern. In other words, there is a significant and positive correlation indicating that the higher the refined carbohydrate consumption, the greater the number of musculoskeletal findings. Third, Figure 6 also points out other statistically significant relationships including **negative** correlations for pantothenic acid (line 5), vitamin E (line 6), niacin (line 7), vitamin B_6 (line 8), vitamin B_1 (line 9), vitamin B_{12} (line 10), vitamin B_2 (line 11), phosphorus (line 12), vitamin A (line 14), and vitamin C (line 15). In these instances, the correlations are significant and negative, suggesting that, as the particular vitamin intake rises, the musculoskeletal findings decline. The additional point should be made that these latter items must be viewed as resistance agents because the groups characterized by the higher vitamin intake show fewer musculoskeletal findings. This is in contrast to the refined carbohydrate determination which suggests that this nutrient is to be viewed as a susceptibility factor. Fourth, while other nutrients do not quite satisfy the five percent confidence level, they nevertheless follow a very logical pattern. For example, the total calories per day (line 16) is a positive correlation as is total sodium intake (line 19). On the other hand, calcium (line 17), isoleucine (line 18), valine (line 20), methionine (line 22), phenylalanine, tryptophan, iron, lysine, threonine, iodine, polyunsaturated fatty acids, leucine, protein, potassium, percentage polyunsaturated fats, magnesium, and fats negatively correlate.

In summary, it appears from this correlation analysis and utilizing a food frequency questionnaire that a number of nutrients appear related to the musculoskeletal disease proneness profile. Sugar and other refined carbohydrates rate as susceptibility factors; all vitamins examined and one

musculoskeletal disease proneness profile as determined from the Cornell Medical Index Health Questionnaire and a food frequency questionnaire

	r	P
1] total carbohydrates (gms)	+0.174	<0.01*
2] approximate refined carbohydrate intake (gms)	+0.171	<0.01*
3] calories from refined carbohydrates	+0.159	<0.01*
4] percentage of calories from refined carbohydrates	+0.143	<0.01*
5] pantothenic acid (mgs)	−0.111	<0.01*
6] vitamin E (I.U.)	−0.094	<0.01*
7] niacin (mgs)	−0.090	<0.01*
8] vitamin B_6 (mgs)	−0.089	<0.01*
9] vitamin B_1 (mgs)	−0.088	<0.01*
10] vitamin B_{12} (mcgms)	−0.086	<0.01*
11] vitamin B_2 (mgs)	−0.080	<0.01*
12] phosphorus (mgs)	−0.073	<0.05*
13] approximate sugar per day (tsps)	+0.071	<0.05*
14] vitamin A (USP units)	−0.067	<0.05*
15] vitamin C (mgs)	−0.063	<0.05*
16] total calories per day	+0.049	>0.05
17] calcium (mgs)	−0.045	>0.05
18] isoleucine (mgs)	−0.043	>0.05
19] total sodium (mgs)	+0.043	>0.05
20] valine (mgs)	−0.039	>0.05
21] ratio Ca/P	−0.035	>0.05
22] methionine (mgs)	−0.033	>0.05
23] phenylalanine (mgs)	−0.033	>0.05
24] tryptophane (mgs)	−0.033	>0.05
25] iron (mgs)	−0.032	>0.05
26] lysine (mgs)	−0.032	>0.05
27] threonine (mgs)	−0.031	>0.05
28] iodine (mgs)	−0.023	>0.05
29] polyunsaturated fatty acids	−0.021	>0.05
30] leucine (mgs)	−0.020	>0.05
31] protein (gms)	−0.018	>0.05
32] potassium (gms)	−0.014	>0.05
33] percentage polyunsaturated to saturated fat	−0.012	>0.05
34] magnesium (mgs)	−0.011	>0.05
35] fats (gms)	−0.006	>0.05

*statistically significant correlation coefficient
April 1976

Figure 6. The musculoskeletal disease proneness profile as determined from the Cornell Medical Index Health Questionnaire and a food frequency questionnaire. It is apparent that there are a number of statistically significant correlation coefficients between various nutrients and the musculoskeletal profile.

musculoskeletal disease **proneness profile** as determined from the Cornell Medical Index Health Questionnaire and a food frequency questionnaire

	correlation analysis	binomial analysis
1] total carbohydrates (gms)	1*	11
2] approximate refined carbohydrate intake (gms)	2*	14
3] calories from refined carbohydrates	3*	2*
4] percentage of calories from refined carbohydrates	4*	1*
5] pantothenic acid (mgs)	5*	3*
6] vitamin E (I.U.)	6*	6*
7] niacin (mgs)	7*	10*
8] vitamin B_6 (mgs)	8*	4*
9] vitamin B_1 (mgs)	9*	8*
10] vitamin B_{12} (mcgms)	10*	5*
11] vitamin B_2 (mgs)	11*	9*
12] phosphorus (mgs)	12*	15
13] approximate sugar per day (tsps)	13*	16
14] vitamin A (USP units)	14*	7*
15] vitamin C (mgs)	15*	12
16] total calories per day	16	23
17] calcium (mgs)	17	13
18] isoleucine (mgs)	18	18
19] total sodium (mgs)	19	26
20] valine (mgs)	20	17
21] ratio Ca/P	21	31
22] methionine (mgs)	22	29
23] phenylalanine (mgs)	23	19
24] tryptophane (mgs)	24	22
25] iron (mgs)	25	25
26] lysine (mgs)	26	21
27] threonine (mgs)	27	24
28] iodine (mgs)	28	27
29] polyunsaturated fatty acids	29	30
30] leucine (mgs)	30	28
31] protein (gms)	31	20
32] potassium (gms)	32	34
33] percentage polyunsaturated to saturated fat	33	33
34] magnesium (mgs)	34	35
35] fats (gms)	35	32

*statistically significant relationship
July 1976

Figure 7. The musculoskeletal disease proneness profile as determined from the Cornell Medical Index Health Questionnaire and a food frequency questionnaire. This summary shows the rating of nutrients in terms of musculoskeletal symptoms and signs as judged by the correlation coefficient technique and by binomial analysis. While there are differences by the two methods, there are striking and significant ($r = 0.880$, $P < 0.01$) relationships.

mineral (phosphorus) must be viewed as resistance agents.

Figure 7 is a summary of the relationship of musculoskeletal symptoms and signs in terms of nutrients as judged by the food frequency questionnaire and as calculated by correlation analysis **versus** binomial calculation. The various nutrients are arrayed in order of decreasing significance. For example, total carbohydrates expressed in grams (line 1) has the highest **correlation coefficient** and is highly statistically significant. In contrast, by **binomial analysis,** it rates number 11 in importance and is not significant. Figure 7 shows that there are differences in the rating of nutrients in terms of the musculoskeletal disease proneness profile. However, there are also remarkable similarities. For example, the calories derived from refined carbohydrates (line 3) rates as number three in terms of correlation coefficient and number two as judged by the binomial analysis, and by both methods the relationship is highly significant. As a matter of fact, the overall correlation coefficient between correlation analysis and binomial analysis is +0.880, $P<0.01$. **In short, utilizing these two different techniques, there are striking significant relationships between nutrients as judged by the food frequency questionnaire and musculoskeletal symptoms and signs measured by these two entirely different statistical devices.**

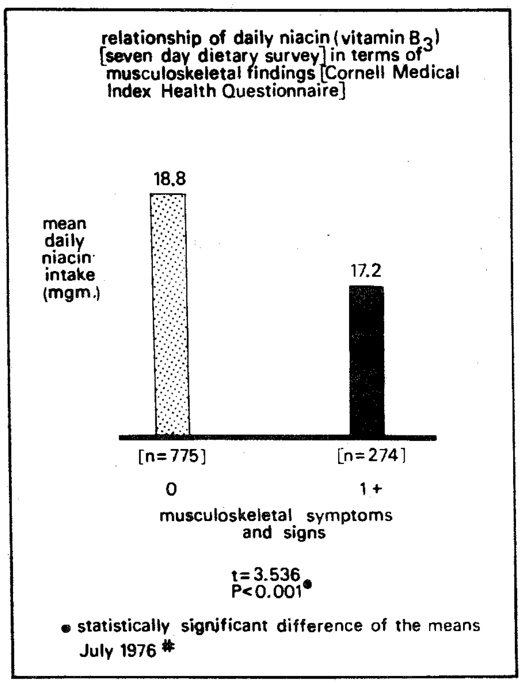

Figure 8. The relationship of the daily niacin intake (as established from a seven-day dietary survey) versus the total number of musculoskeletal symptoms and signs (as judged from the Cornell Medical Index Health Questionnaire). The subjects characterized by 1+ musculoskeletal findings report a statistically significantly lower intake of vitamin B_3.

Once again, because of the newness of the subject, it was felt advisable to recheck all data using a **different** dietary survey. It should be recalled that earlier data in this report were derived from a **food frequency questionnaire.** Consideration will now be given to a **seven-day dietary survey,** and it will be compared to the musculoskeletal profile as derived from the Cornell Medical Index Health Questionnaire.

Figure 8 is a **binomial** analysis of the relationship of nicotinic acid to musculoskeletal symptoms and signs. It will be observed that those without musculoskeletal findings (the stippled column) consume approximately 19 mgs of vitamin B_3 per day; for those with 1+ complaints (black column), the intake is 17 mgs. This eight percent difference is highly significant ($t=3.536$, $P<0.001$).

It would, therefore, appear that subjects with musculoskeletal findings are more apt to consume relatively less niacin than those free of such clinical symptoms and signs.

Figure 9 is a summary of the binomial relationship of the musculoskeletal scores in terms of **all** nutrients studied by the seven-day dietary technique. Additionally, the point should be made that the nutrients have been arrayed in decreasing order of statistical importance as determined by the t value. Figure 9 deserves particular attention for four reasons. First, it is clear that nicotinic acid is number one in statistical importance and must be viewed as a resistance agent. Second, fat is number two. Specifically, those consuming the lesser amount of fat report the greater number of musculoskeletal complaints. Therefore, fat must also be recognized as a resistance agent because those con-

musculoskeletal disease proneness profile as determined from the Cornell Medical Index Health Questionnaire and a seven-day dietary survey

	complaints 0	complaints 1+	% difference	t	P
1] nicotinic acid (mgs)	19	17	8	3.536	<0.001*
2] fat (gms)	101	95	6	2.565	<0.025*
3] iodine (mgs)	0.06	0.05	9	2.500	<0.025*
4] iron (mgs)	14	13	5	2.364	<0.025*
5] total protein (gms)	100	95	5	2.342	<0.025*
6] animal protein (gms)	79	75	6	2.327	<0.025*
7] base	30	29	6	2.207	<0.050*
8] vitamin B_1 (mgs)	1.0	0.9	5	1.967	<0.050*
9] total calories	1992	1920	4	1.950	>0:050
10] phosphorus (gms)	1.4	1.4	4	1.787	>0.050
11] refined carbohydrate (gms)	65	69	6	1.510	>0.100
12] vitamin A (IU)	9604	8957	7	1.229	>0.200
13] vitamin B_2 (mgs)	1.9	1.8	4	1.280	>0.200
14] vitamin C (mgs)	142	137	4	0.964	>0.200
15] total carbohydrate (gms)	158	161	2	0.893	>0.200
16] unrefined carbohydrate (gms)	94	92	2	0.854	>0.200
17] vitamin D (IU)	91	87	5	0.584	>0.500
18] vegetable protein (gms)	22	22	1	0.264	>0.500
19] acid	37	37	1	0.198	>0.500
20] calcium (gms)	0.79	0.78	1	0.189	>0.500

*statistically significant difference of the means
May 1976

Figure 9. The musculoskeletal disease proneness profile as derived from the Cornell Medical Index Health Questionnaire and a seven-day dietary survey. It is evident that there are a number of statistically significant relationships between various nutrients and the musculoskeletal profile.

suming the greater amount of fat show fewer clinical findings. Third, Figure 9 also reports other statistically significant relationships including iodine (line 3), iron (line 4), total protein (line 5), animal protein (line 6), and vitamin B_1 (line 8). Finally, even when some of the relationships do not meet the five percent confidence level for statistical significance, there are still interesting observations. For example, vitamin A intake (line 12) is lower in those with musculoskeletal findings. This is also true for vitamin B_2 (line 13), vitamin C (line 14), and vitamin D (line 17).

In summary, it appears from this binomial analysis and utilizing a seven-day dietary survey technique, that a number of nutrients relate to the musculoskeletal disease proneness profile. Specifically, fat, protein and several vitamins and minerals must be viewed as resistance agents.

Figure 10 depicts the relationship of the daily niacin intake (as established from the seven-day dietary survey) versus the total number of musculoskeletal symptoms and signs (as judged from the Cornell Medical Index Health Questionnaire). Shown on the abscissa are the musculoskeletal symptoms and signs depicted as 0, 1, 2, and 3+. Described on the ordinate is the mean daily niacin intake expressed in milligrams. It is clear that those 775 subjects with no musculoskeletal symptoms and signs consumed the greatest daily intake of niacin (18.8 milligrams). Conversely, the 29 subjects with 3+ musculoskeletal symptoms and signs are consuming the least amount of daily niacin (15.7 milligrams). As a matter of fact, as the number of musculoskeletal findings rise (moving from left to right on the abscissa), the daily niacin intake (on the ordinate) declines. Finally, there is a statistically significant negative correlation ($r=-0.107$, $P<0.01$).

In the light of these data, it is fair to conclude that subjects consuming the greatest amount of niacin show the fewest musculoskeletal findings.

Figure 11 is a **summary** of the relationship of the musculoskeletal scores in terms of **all** nutrients studied by the seven-day dietary questionnaire. Additionally, the point should be made that the nutrients have been arranged in decreasing order of statistical importance as determined by the correlation coefficient. Figure 11 deserves particular attention for four reasons. First, it is clear that the nicotinic acid intake expressed in milligrams is number one in order of statistical importance. Since the correlation is negative, this suggests that the higher the niacin intake, the fewer the number of musculoskeletal symptoms and signs. Second, it will be noted that other measures are also significantly and negatively related indicating once again that the higher the nutrient, the fewer the musculoskeletal findings. In the light of earlier definitions, nicotinic acid (line 1) through total calories (line 9) must all be viewed as resistant factors because the group characterized by the higher intake shows the fewest number of musculoskeletal findings. Third, it is noteworthy that the only positive correlation, admittedly not significant, is refined carbohydrates. Lastly, while other nutrients do not

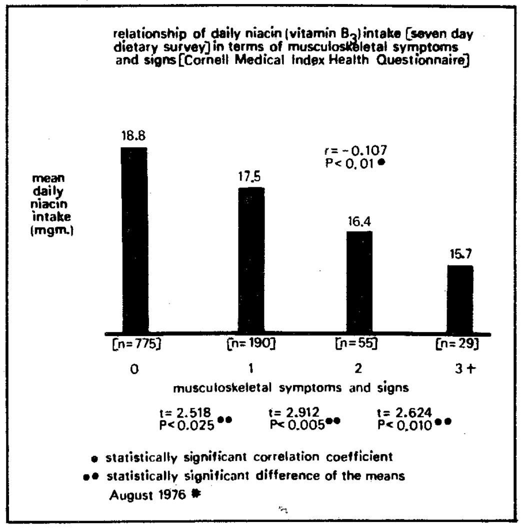

Figure 10. The relationship of the daily niacin intake (as established from a seven-day dietary survey) versus the total number of musculoskeletal symptoms and signs (as judged from the Cornell Medical Index Health Questionnaire). As the number of musculoskeletal findings rise (moving from left to right on the abscissa), the daily niacin intake (on the ordinate) declines. There is a statistically significant negative correlation ($r = -0.107$, $P < 0.01$).

musculoskeletal disease proneness profile as determined from the Cornell Medical Index Health Questionnaire and a seven-day dietary survey

	r	P
1] nicotinic acid (mgs)	−0.107	<0.01*
2] base	−0.091	<0.01*
3] fat (gms)	−0.087	<0.01*
4] iron (mgs)	−0.086	<0.01*
5] total protein (gms)	−0.083	<0.01*
6] animal protein (gms)	−0.082	<0.01*
7] iodine (mgs)	−0.076	<0.05*
8] vitamin B_1 (mgs)	−0.071	<0.05*
9] total calories	−0.063	<0.05*
10] vitamin C (mgs)	−0.051	>0.05
11] vitamin D (IU)	−0.050	>0.05
12] vitamin B_2 (mgs)	−0.044	>0.05
13] unrefined carbohydrate (gms)	−0.033	>0.05
14] acid	−0.025	>0.05
15] vegetable protein (gms)	−0.024	>0.05
16] refined carbohydrate (gms)	+0.022	>0.05
17] vitamin A (IU)	−0.016	>0.05
18] phosphorus (gms)	−0.011	>0.05
19] total carbohydrate (gms)	−0.004	>0.05
20] calcium (gms)	−0.003	>0.05

*statistically significant correlation coefficient
May 1976

Figure 11. The musculoskeletal disease proneness profile as determined from the Cornell Medical Index Health Questionnaire and a seven-day dietary survey. It is apparent that there are a number of statistically significant correlation coefficients between various nutrients and the musculoskeletal profile.

quite satisfy the five percent confidence level, they nevertheless follow a very logical pattern. For example, vitamin C (line 10) is negatively related and just misses being of statistical significance.

In summary, it appears from this correlation analysis and utilizing a seven-day dietary questionnaire, that a number of nutrients appear related to the musculoskeletal disease proneness profile. Specifically, fat, protein, total calories and several vitamins and minerals must be viewed as resistant agents.

Figure 12 is a summary of the relationship of musculoskeletal symptoms and signs in terms of nutrients as judged by the seven-day dietary questionnaire and as calculated by correlation analysis versus binomial calculation. The various nutrients are arrayed in order of decreasing significance. For example, nicotinic acid expressed in milligrams (line 1) has the highest correlation coefficient and is highly statistically significant. Also, by binomial analysis, it also rates number one in importance and significance. Figure 12 shows that there are differences in the rating of nutrients in terms of the musculoskeletal disease proneness profile. However, there are also remarkable similarities. As a matter of fact, the overall correlation coefficient between correlation analysis and binomial analysis is $+0.798$, $P<0.01$. **In short, utilizing these two different techniques, there are striking significant relationships between nutrients as judged by the seven-day dietary survey and musculoskeletal symptoms and signs measured by these two entirely different statistical devices.**

musculoskeletal disease proneness profile
as determined from the Cornell Medical
Index Health Questionnaire and a
seven-day dietary survey

	correlation analysis	binomial analysis
1] nicotinic acid (mgs)	1*	1*
2] base	2*	7*
3] fat (gms)	3*	2*
4] iron (mgs)	4*	4*
5] total protein (gms)	5*	5*
6] animal protein (gms)	6*	6*
7] iodine (mgs)	7*	3*
8] vitamin B_1 (mgs)	8*	8*
9] total calories	9*	9
10] vitamin C (mgs)	10	14
11] vitamin D (IU)	11	17
12] vitamin B_2 (mgs)	12	13
13] unrefined carbohydrate (gms)	13	16
14] acid	14	19
15] vegetable protein (gms)	15	18
16] refined carbohydrate (gms)	16	11
17] vitamin A (IU)	17	12
18] phosphorus (gms)	18	10
19] total carbohydrate (gms)	19	15
20] calcium (gms)	20	20

*statistically significant relationship
July 1976

Figure 12. The musculoskeletal disease proneness profile as determined from the Cornell Medical Index Health Questionnaire and a seven-day dietary survey. This summary shows the ratings of nutrients in terms of musculoskeletal symptoms and signs as judged by the correlation coefficient technique and by binomial analysis. While there are differences by the two methods, there are striking and significant ($r = +0.798$, $P < 0.01$) relationships.

Discussion

It is appropriate to compare the findings outlined here with regard to the musculoskeletal disease proneness profile with other such profiles reported elsewhere. For example, there is now information in the literature regarding a predictive profile for mental illness[2], for oral pathology[3], and for the syndrome of sickness[4].

The most glaring point to be made from a comparison of all of these proneness profiles is that those factors which serve as resistance agents, namely variables which protect against disease, are the same regardless of the profile. Also, those elements which may be viewed as susceptibility factors, items which encourage disease, are also essentially the same in every profile. It is true that the order of priority may vary from one to another proneness profile. Whether this is because there are different priorities or whether the measuring technique is such that being in fourth place on one profile and in eighth place on another, is simply a technical problem.

What is exciting is the fact that the musculoskeletal disease proneness profile, the first of its kind as far as we can determine, indicates that a number of dietary factors encourage and others discourage clinical symptoms and signs.

It should be recalled that, after the initial studies were performed, group health education lectures were instituted providing the participants with analyses of their own dietary habits and how they could be improved. One year later, the dietary surveys and the questionnaires were repeated. Hence, by this method, it was possible to analyze the relationship of **change** in dietary habits versus **change** in musculoskeletal symptoms and signs.

For example, Figure 13 is an analysis of the ef-

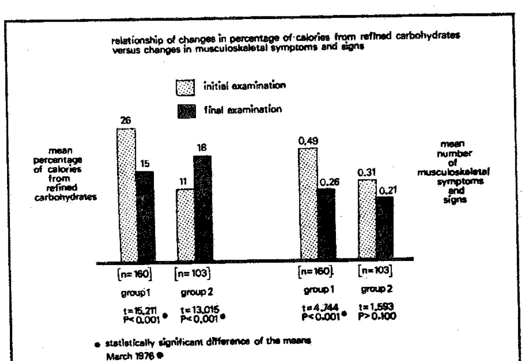

Figure 13. The effect of changes in the percentages of daily calories derived from refined carbohydrates (as measured by the food frequency questionnaire) versus changes in reported musculoskeletal symptoms and signs (as measured from the Cornell Medical Index Health Questionnaire).

fect of changes in the percentage of calories derived from refined carbohydrate foods (as measured from the food frequency questionnaire) versus changes in reported musculoskeletal symptoms and signs. One hundred sixty subjects (group 1) decreased the percentage of calories from refined carbohydrates. In contrast, 103 (group 2) chose to increase the percentage of calories from refined carbohydrates. Obviously, since group 1 was selected because they decreased and group 2 was chosen because they increased carbohydrate consumption, there is a very high and significant change in groups 1 and 2 on the left in Figure 13 as pictured by $t=15.211$, $P<0.001$, and $t=13.015$, $P<0.001$. An examination of the columns on the right shows that there was a reduction in number of musculoskeletal symptoms and signs in both groups. However, the decline was significant only in group 1 representing the subjects who **decreased** the percentage of calories from refined carbohydrates. Group 1 (left) is characterized by a decrease in daily calories derived from refined carbohydrates, and the change is highly significant ($t=15.211$, $P<0.001$). This is paralleled by a significant reduction ($t=4.744$, $P<0.001$) in the number of musculoskeletal symptoms and signs. Group 2 is characterized by an increase in the percentage of calories derived from refined carbohydrates. This is very significant as shown by $t=13.015$ and $P<0.001$. This group does not show a statistically significant reduction in musculoskeletal complaints as shown by $t=1.593$ and $P<0.100$.

It would appear that, within the limits of this study, changes in refined carbohydrate intake are paralleled by changes in musculoskeletal findings; when refined carbohydrate increases, musculoskeletal symptoms and signs increase; when refined carbohydrate decreases, the musculoskeletal picture improves.

Figure 14 portrays in pictorial fashion the effect of changes in the daily vitamin C intake (as measured from the food frequency questionnaire) versus changes in reported musculoskeletal symptoms and signs. Three hundred nine subjects (group 1) increased the daily vitamin C intake. In contrast, 82 chose to decrease the daily vitamin C consumption. Obviously, since the subjects (group 1) were selected because they increased and those in group 2 were chosen because they decreased vitamin C, there is a very high and significant change in groups 1 and 2 on the left in Figure 14 as pictured by $t=21.928$, $P<0.001$ and $t=9.168$, $P<0.001$. An examination of the columns on the right shows that there was a significant reduction in the number of musculoskeletal symptoms and signs in **both** groups. However, the decline was much more significant in the group characterized by the increase in vitamin C as shown by $t=5.019$ and $P<0.001$ versus group 2 with $t=2.452$ and $P<0.025$.

With and without a change in daily vitamin C consumption, the musculoskeletal picture improves. However, in the face of an increase in vitamin C, the clinical improvement is much greater.

Figure 15 summarizes graphically the effect of changes in daily vitamin E intake (as measured in the food frequency questionnaire) versus changes in reported musculoskeletal clinical findings. Two hundred ninety subjects (group 1) increased the daily vitamin E intake. In contrast, 73 (group 2) chose to decrease the daily vitamin E consumption. Since group 1 and group 2 were selected because they increased and decreased the vitamin E intake respectively, there are obviously very high and significant changes in these two groups on the left in Figure 15 ($t=17.571$, $P<0.001$ and $t=5.071$, $P<0.001$). A study of the columns on the right shows that there was a statistically significant reduction in the number of musculoskeletal symptoms and signs in **both** groups. However, the decline was much more significant in group 1 characterized by an increase in vitamin E ($t=4.883$, $P<0.001$)

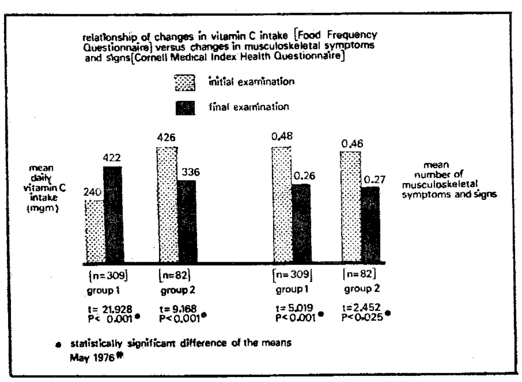

Figure 14. The effect of changes in vitamin C intake derived from the food frequency questionnaire versus changes in reported musculoskeletal symptoms and signs as ascertained from the Cornell Medical Index Health Questionnaire.

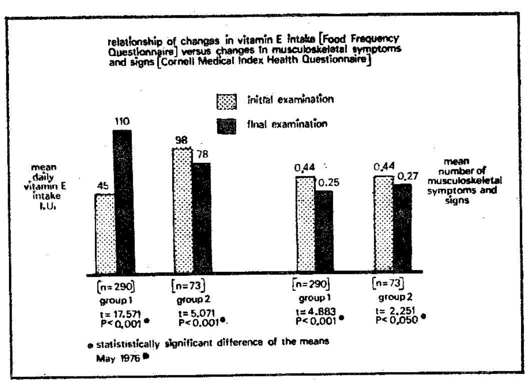

Figure 15. The effect of changes in daily vitamin E intake determined from the food frequency questionnaire versus changes in reported musculoskeletal findings as derived from the Cornell Medical Index Health Questionnaire.

than in group 2 subjects who decreased E intake ($t=2.251$, $P<0.050$).

It appears that the changes with vitamin E alone are similar to the changes with vitamin C alone. When vitamin E is increased, the clinical improvement is greater.

The observations with changes in single nutrients is marginal. In the case of the refined carbohydrates, the evidence seems clear that a reduction in the calories derived from refined carbohydrate food nets a significant change in musculoskeletal findings. This does not seem to occur in those increasing the refined carbohydrate consumption. However, with regard to vitamin C and vitamin E alone, the evidence is not so clear though, statistically, those increasing vitamin C and vitamin E singly show a much more significant reduction in musculoskeletal findings.

Since all nutrients are interrelated, the effect of nutrient intake on musculoskeletal findings is more pronounced when one looks at combinations of the various nutrients. Figure 16 analyzes the effect of changes both in daily vitamin C and vitamin E intake as determined from the food frequency questionnaire. It is very evident from this illustration that there is a very marked reduction in the number of musculoskeletal findings. In contrast, in Figure 17 where the mean daily vitamin C and vitamin E intake was reduced, there is no significant change in the mean number of musculoskeletal symptoms and signs. Hence, when studied in combination, vitamin C and vitamin E are more meaningful than when examined singly.

The evidence seems clear that the changes in the musculoskeletal syndrome are more meaningful when examined in the light of changes in both vitamins C and E than when viewed singly. When both vitamins C and E are increased, the musculoskeletal symptoms and signs significantly decline. When both vitamins C and E are not increased, there is no significant change.

Finally, Figure 18 shows the changes in the musculoskeletal symptoms and signs in terms of a decrease in the percentage of daily calories derived from refined foods along with an increase in vita-

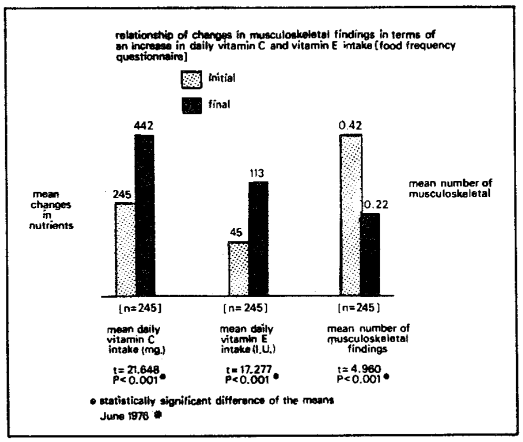

Figure 16. The effect of changes both in daily vitamin C and vitamin E intake as determined from the food frequency questionnaire versus changes in reported musculoskeletal symptoms and signs as obtained from the Cornell Medical Index Health Questionnaire. It is abundantly clear that, in subjects increasing both daily vitamin C and vitamin E, there is a highly significant reduction in the mean number of musculoskeletal findings.

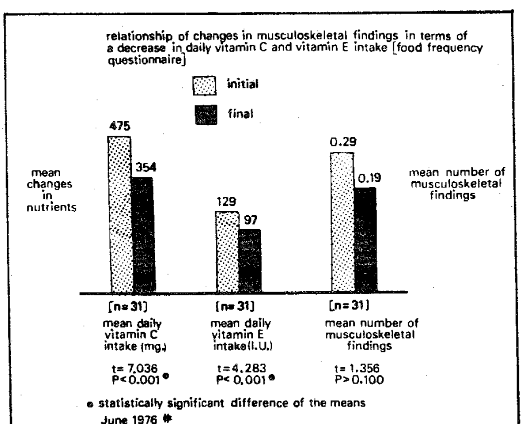

Figure 17. The effect of changes in the daily intake of both vitamin C and vitamin E as derived from the food frequency questionnaire versus changes in reported musculoskeletal symptoms and signs as measured by the Cornell Medical Index Health Questionnaire. It is clear that, in those subjects decreasing both vitamin C and vitamin E, there is no statistically significant change in the mean number of musculoskeletal findings.

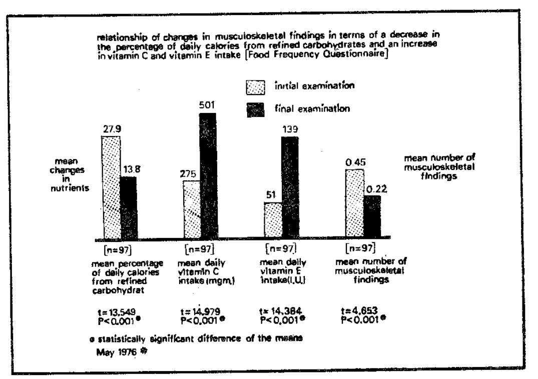

Figure 18. The effect of changes characterized by a decrease in the percentage of daily calories derived from refined carbohydrates in conjunction with an increase in both vitamin C and vitamin E intake as measured by the food frequency questionnaire versus reported musculoskeletal symptoms and signs as measured by the Cornell Medical Index Health Questionnaire. It is clear that in those subjects decreasing sugar intake and increasing both vitamin C and vitamin E intake there is a statistically significant reduction in the number of musculoskeletal complaints from 0.4 to 0.22 with a $t=4.653$ and a $P<0.001$.

min C and in vitamin E. It will be noted in Figure 18 that the mean number of musculoskeletal findings is literally cut in half. In contrast, Figure 19 shows the changes in the mean number of musculoskeletal findings in subjects increasing the percentage of daily calories from refined carbohydrate foods in connection with a decrease in both vitamins C and E. The answer is no change at all.

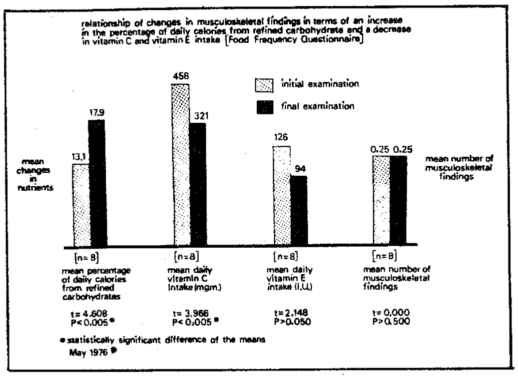

Figure 19. The effect of the combined changes characterized by an increase in the percentage of daily calories derived from refined carbohydrates along with a decrease in both daily vitamin C and vitamin E as determined from a food frequency questionnaire versus the clinical changes in reported musculoskeletal findings as determined from the Cornell Medical Index Health Questionnaire. The evidence shows that in those subjects increasing sugar intake along with a reduction of vitamin C and vitamin E there is no statistically significant change in the mean number of musculoskeletal findings.

There is no question but that the musculoskeletal syndrome significantly improves when refined carbohydrates are reduced and vitamins C and E are increased. On the other hand, there is no change in the musculoskeletal findings when refined carbohydrate is not reduced and with no increase in vitamins C and E. ■

References

1. United States Department of Health, Education, and Welfare, "Prevalence of Chronic Skin and Musculoskeletal Conditions: United States-1969," DHEW Publication No (HRA) 75-1519, Series 10: No 92, August 1974, Washington, DC, Superintendent of Documents, United States Government Printing Office.
2. Cheraskin, E. and Ringsdorf, W. M., Jr, "The Mental Illness Proneness Profile," Alabama J Med Sci, Vol 10, No 1, 1973, pp 32-45.
3. Cheraskin, E., Ringsdorf, W. M., Jr, Hicks, B. S., and Romano, D. M., "The Prevention of Oral Disease," J Int Acad Prev Med, Vol 2, No 1, 1975, pp 22-52.
4. Cheraskin, E., Ringsdorf, W. M., Jr, Michael, D. W., Hicks, B. S., and Wright, W., Jr, "The Pluses and Minuses of the Syndrome of Sickness," J Amer Soc Prev Dent, Vol 1, No 6, 1971, pp 26-28, 44-48, 58.

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