The effect of a vegan diet health and social care essay

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ABSTRACT

Calcium, Vitamin D and protein are vital for developing peak bone mass, however typical vegan diets have been shown to be lacking in these vital nutrients. In contrast vegan populations have been shown to engage in more physical activity than omnivore counterparts. The aim of the present study was to evaluate what effect a vegan diet and differing activity levels would have on calcaneal bone ultrasound attenuation (BUA) in comparison with omnivore counterparts. In total 64 vegan were recruited from the Bristol Vegan Fayre over the course of 5 years, in addition to 35 omnivore participants recruited from a university. All participants had their diets, bone-specific physical activity and calcaneal bone ultrasound attenuation measured and analysed via food frequency questionnaires (FFQ), bone-specific physical activity questionnaires (BPAQ) and quantitative ultrasound scans (QUS) respectively. The results revealed that vegans consumed more calcium, phosphorus, magnesium and zinc than omnivores; while omnivores consumed more vitamin D. Protein intake was not significantly different between vegan and omnivores. Omnivore's were found to have significantly higher past (60. 3 ± 63. 6 versus 47. 7 ± 63. 0), current (12. 3 ± 15. 7 versus 6. 3 ± 10. 3), and total (36. 3 ± 34. 6 versus 27. 0 ± 31. 4) mean BPAQ scores when compared to vegans. Raw BUA measurements were converted into BUA T-Scores and BUA Z-Scores; Omnivores had a higher mean BUA T-Score when compared to vegans (0. 02 ± 0. 97 versus -0. 39 ± 0. 85) but no significant difference could be found in regards to mean BUA Z-Scores (-0. 09 ± 0. 97 versus -0. 11 ± 0. 86). No statistically significant

differences could be found between BPAQ scores, BMI, years vegan or protein, calcium and vitamin D intakes in vegans in either the low, normal or high BUA Z-Score categories. The result was the same in the low, normal and high categories in the omnivore group with the exception of the BPAQ scores which were shown to positively correlate with increased BUA Z-Scores. In conclusion it was found that vegans consume more calcium and other bone health related micronutrients, except vitamin D, and participate in less physical activity than omnivores; but this does not equate to a difference in BUA Z-Score's between the two groups.

INTRODUCTION

The concept that a well balanced vegan diet is appropriate for all stages of the life-cycle including gestation, lactation, infancy, childhood, and adolescence is supported by the American Dietetic Association and Dieticians of Canada (1), the British Dietetic Association also promotes vegan diets as both nutritious and healthy. A survey conducted in 2007 by the British government revealed that 2% of UK residents self identified themselves as vegan (2). When compared to ovolacto-vegetarians and meat eaters, a common finding has been a significantly reduced calcium and protein intake in vegan diets (3, 4). With such a significant number of individuals following a restrictive diet (no meat, fish, dairy, eggs, honey or any other animal products), there is a growing need to determine whether vegan diets are a cause for concern when it comes to bone health (5). There is cause for concern when analysing vegan intakes of micronutrients that are beneficial for bone development; calcium levels of vegans have been found to be consistently lower than omnivores (3, 6–8), in addition to consistently

low vegan vitamin D consumption (3, 7-9). Osteoporosis is a growing public health concern due to the large percentage of the population affected and its consequences; it has been discovered that approximately 20% of Caucasian women and 10% of Caucasian men aged over 60 have osteoporosis (10). The most serious consequence of osteoporosis is fragility fracture, particularly of the hip, which is associated with increased mortality and disability (11, 12), considerable health care costs (11, 13) and marked deterioration in quality of life (14). Physical activity is also strongly linked to bone health (15–18). A systematic review conducted by Wallace et al. (18) investigated 24 post-menopausal studies and 8 pre-menopausal studies regarding exercise and BMD, the review discovered that exercise clearly slowed down the rate of bone loss at the spine at a similar rate in both groups when compared to inactive matched controls (18). Studies have shown that non-meat eating populations are more likely to participate in moderate to strenuous exercise more frequently than their meat eating counterparts (19), and vegans were also shown to have the highest occurrence of manual work (3). This could be an explanation for the inconclusiveness of current research regarding bone mineral density and veganism. Thus nutrition and physical activity are identified as important components in the prevention of osteoporosis primarily because it is modifiable by the population (6, 20). Therefore this study aims to investigate if a relationship exists between a vegan diet and physical activity on bone quality.

METHODS

Subjects

Ethical approval was gained for this study from the British College of Osteopathic Medicine's Ethics committee and informed written consent was obtained from each participant. 229 vegan male and pre-menopausal female subjects between the ages of 20 and 50 years (33. 0 ± 7. 5 years) were recruited from the Bristol Vegan Fayre over the course of 2005-2009, while 35 omnivore subjects (25. 2 ± 4. 4 years) were students recruited from the British College of Osteopathic Medicine and tested using the same apparatus in a university research laboratory. One hundred and sixty-five of the vegan subject data collected was excluded; this was due to the subjects not having completed the bone physical activity questionnaires, which was deemed imperative for the study to be accurate and reliable.

General health and bone health assessment

The first part of the questionnaire was used to gather general information such as age, date of birth, cigarette usage, family history of osteoporosis, duration of veganism, history of corticosteroids, fracture history and other bone-health related questions to determine if subjects were appropriate for the study.

Assessment of dietary intake

The vegan and omnivore subjects were required to complete a food frequency questionnaire (FFQ) on the same day as the quantitive ultrasound (QUS) measurement. Vegan participants completed a vegan-specific questionnaire containing 220 vegan food choices, while omnivores

completed an omnivore-specific FFQ. The FFQ's design allowed an assessment of the amount of servings consumed by participants within the duration of a month. Subjects were required to tick a box which indicated how frequently an item of food was consumed, the options ranged from never to more than six times a day. A representation of the questionnaires format is included in Table 1. Table 1. The FFQ format and options, included is the multiplication used to estimate the monthly weight of each food consumed.

NEVER <1/ MONTH1-3/MONTH1/ WEEK2-4/ WEEK5-6/ WEEK1/ DAY2-3/ DAY4-5/ DAY6+/ DAYMultiplier00. 524. 312. 923. 73075135180WHITE BREAD, SLICED

BROWN BREAD, AVERAGE

Each food item's weight from the FFQ's was then multiplied by a corresponding value that allowed an estimation of the monthly weight of each food consumed. This estimated monthly weight was entered into the computer diet analysis program DietPlan6, which allowed a comprehensive monthly nutrient intake of the subjects to be calculated.

Assessment of bone specific physical activity

Both groups were required to complete a bone-specific physical activity questionnaire (BPAQ). The BPAQ, created by Weeks and Beck (21), works on the basis that some forms of exercise are more osteogenic than others and it has been shown to accurately predict indices of bone strength at clinically relevant sites in both men and women (21). It is designed to predict parameters of bone strength in healthy, young adults by recording the

specific types of exercise the subject has previously engaged in and currently engages in, in addition to the frequency and number of years the subject has engaged in the activities. This information is then entered into a BPAQ program which produces a current, past and total BPAQ score.

Bone Ultrasound Attenuation measuring

As the study involved testing subjects at various geographical sites, the choice of determining bone integrity and fracture risk had to be portable and easy to use, therefore bone densitometry via DEXA scanning, which is usually the gold standard for analysing risk fracture, was not an option. Instead quantitative ultrasound of the calcaneus bone was used due to its equally predictive accuracy of detecting osteoporosis when compared to bone mineral density measurements (DEXA) (22), also because of its fast performance, low cost, portability and absence of radiation exposure (23, 24). All subjects quantitative heel ultrasound variables were measured via a McCue Cubaclinical II ultrasound scanner by a trained supervisor who underwent previous relevant training. The scanner was calibrated daily. Two bone ultrasound attenuation (BUA) measurements were carried out on both feet in each subject; if a difference between the two results existed that was greater than 5 dB/MHz a third reading was taken. The results were recorded onto specialised computer software. Due to BUA data having a natural decrease in regards to increasing age, the raw BUA data was translated into BUA T-scores and BUA Z-scores, which are age and race adjusted measurements. The calculations for which are: age matched population standard deviationZ score = measurement value – age matched mean(25)young adult population standard deviationT score = measurement

value – young adult mean (25)As the equations show, Z scores are a more accurate method of determining bone strength in a young subject group as the score is specifically age-matched, therefore removing the confounding factors of chronological age and the influence of differences in the age-related decline of T-scores (25). For these reasons Z scores were the primary measure of bone strength used in this study. The subject's height and weight, to the nearest 0. 01 metre and 0. 1 kilogram respectively, were recorded on the day of the BUA recording.

Statistical analysis

Sigmaplot 12 was used for the statistical analysis and testing. Microsoft Excel was also used extensively to store the raw data and perform necessary adjustments so that further analysis could be performed such as calculating the mean, standard deviation and frequency of multiple data sources. The general health questionnaire, FFQ multiplication and BPAQ results were all recorded with Microsoft Excel. The data was analysed using t test and one-way ANOVA. For statistical tests a p value of <0. 05 was considered to indicate a significant difference. When the data was not normally distributed Mann-Whitney Rank Sum tests or Kruskal-Wallis One Way Analysis of Variance on ranks were performed.

RESULTS

General health information

No statistically significant differences were found between omnivores and vegans regarding weight, height, body mass index (BMI); although significant differences did exist between the number of subjects, age, ratio of females

to males and percentage of smokers in the vegan and omnivore groups (Table-1). In regards to a familial history of osteoporosis 20% of omnivores did have a history compared to 12. 5% of vegans. In regards to supplementation 12. 5% of vegans were found to take calcium supplementation, while no omnivores were found to consume calcium supplementation but 12. 5% were found to consume Vitamin D. The supplementational intake of these participants was not included in the overall micronutrients of the diet due to unreliable recording of quantities of these supplements. Table 1. Characteristics of vegan and omnivore subjects. VegansOmnivoresNumber 64 35Age (years)33. 0 ± 7. 525. 2 ± 4. 4Females 48 22Males 16 13Weight (kg)65. 6 ± 10. 4 67. 8 ± 10. 9Height (m)1. 67 ± 0. 081. 71 ± 0. 10BMI (kg/m2)23. 4 ± 3. 123. 2 ± 2. 7Smokers (%) 1. 5% 17. 1%

Dietary results

A comparison of macronutrient and micronutrient intakes that are known to influence bone health revealed that vegan subjects were found to consume significantly more calories, fat, carbohydrate, calcium (p = 0. 01), magnesium, zinc and copper than the omnivore group. The omnivore subjects had significantly higher intakes of Vitamin D and Vitamin B12 (p = <0. 001 for both). No significant difference in reported intakes could be found for protein (p = 0. 444), also the dietary ratio of calcium to phosphorus (Ca: P) was not found to be different between either group. Table 2. Dietary intakes of macronutrients and micronutrients known to affect bone mineral content (excluding supplements)VegansOmnivoresp Value(n = 64) (n= 35)Energy (kcal)2935. 5 ± 947. 42186. 6 ± 845. 2p = <0. 001Protein intake

(g) 101. 2 ± 39. 8 96. 4 ± 37. 6p = 0. 444 (NS)Carbohydrate (g)364. 0 ± 137. 3 228. 8 ± 114. 9 p = <0. 001Fat (g) 117. 0 ± 35. 0 99. 4 ± 39. 0p = 0. 024Calcium intake (mg)1193. 1 ± 509. 1950. 9 ± 375. 6p = 0. 010Phosphorus (mg)2000. 9 ± 689. 61652. 5 ± 702. 9p = 0. 027Ca: P 0. 60 ± 0. 15 0. 59 ± 0. 14p = 0. 689 (NS)Zinc (mg) 14. 1 ± 5. 3 11. 9 ± 5. 5p = 0. 019Magnesium (mg)765. 2 ± 294. 8437. 8 ± 308. 3p = <0. 001Copper (mg) 3. 70 ± 1. 53 2. 23 ± 1. 91p = <0. 001Vitamin D intake (ug) 0. 54 ± 0. 57 3. 45 ± 1. 81p = <0. 001Vitamin B12 (ug) 0. 52 ± 0. 67 5. 42 ± 2. 00p = <0. 001

BUA readings, BUA – T and BUA – Z scores.

BUA T-scores were found to be significantly higher in omnivores (Mean: 0. 02 ± 0. 97) than vegans (Mean: -0. 39 ± 0. 85), but a comparison of the BUA Z-scores found that no significant difference existed between vegans (Mean: -0. 10 ± 0. 89) and omnivores (Mean: -0. 09 ± 0. 97). BUA Z-scores are considered the most appropriate measure for use in premenopausal women, men under the age of 50, and in children (26), therefore it is the most relevant score for this study. Table 3. BUA T-scores and Z-scoresVegansOmnivoresp Value(n = 64) (n = 35)BUA – T SCORE-0. 39 ± 0. 850. 02 ± 0. 97 p = <0. 001BUA – Z SCORE-0. 10 ± 0. 89 -0. 09 ± 0. 97 p = 0. 460 (NS)Table 4. Comparison of differing factors in low, normal and high groups of BUA measurements. VegansLow BUA-Z Normal BUA-Z High BUA-Z p Value(n = 9) (n = 49) (n = 6)BPAQ score (Total) 15. 2 ± 14. 9 30. 8 ± 34. 4 13. 4 ± 8. 7 p = 0. 425 (NS)Years vegan 6. 6 ± 7. 2 7. 4 ± 6. 9 5. 9 ± 7. 0 p= 0. 802 (NS)Vegetarian prior (%) 88. 9% 85. 7% 83. 3%-Duration (years) 4. 9 ± 6. 6 10. 7 ± 8. 3 11. 9 ± 8. 0 p = 0. 538 (NS)BMI (kg/m2) 22. 5 ± 3. 3 23. 3

± 3. 1 26. 1 ± 2. 3 p = 0. 503 (NS)Protein (g) 121. 4 ± 40. 0 100. 1 ± 40. 7 80. 0 ± 15. 1 p = 0. 131 (NS)Calcium (mg) 1409. 4 ± 649. 4 1172. 4 ± 500. 2 1038. 5 ± 268. 1 p = 0. 328 (NS)Vitamin D (ug) 0. 67 ± 0. 50 0. 49 ± 0. 54 0. 86 ± 0. 84 p = 0. 209 (NS)OmnivoresLow BUANormal BUA High BUA p Value(n = 6) (n = 24) (n = 5)BPAQ score (Total) 24. 0 ± 17. 4 33. 2 ± 30. 0 71. 5 ± 45. 9 p = 0. 048BMI (kg/m2) 21. 7 ± 2. 623. 1 ± 2. 5 24. 7 ± 3. 0 p = 0. 205 (NS)Protein (g) 82. 6 ± 35. 7 100. 7 ± 38. 7 98. 1 ± 39. 6 p = 0. 593 (NS)Calcium (mg) 1020. 9 ± 264. 4 960. 4 ± 422. 1 849. 1 ± 263. 3 p = 0. 585 (NS)Vitamin D (ug) 3. 62 ± 1. 353. 46 ± 2. 06 3. 69 ± 1. 35 p = 0. 713 (NS)

Bone physical activity questionnaires

Omnivore's were found to have significantly higher past (60. 3 ± 63. 6 versus 47. 7 ± 63. 0), current (12. 3 ± 15. 7 versus 6. 3 ± 10. 3), and total (36. 3 ± 34. 6 versus 27. 0 ± 31. 4) mean BPAQ scores when compared to vegans (Table 5). The 95% confidence intervals found for the mean differences between two groups were: Total BPAQ, 7. 8-10. 8; Current BPAQ, 2. 8-5. 3; Past BPAQ, 15. 8-21. 1. In the vegan group, low impact activities, such as yoga were most common, whereas in the omnivore group higher impact activities, such as rugby, were more common.

Table 5.

Bone physical activity questionnaire score comparisons. VegansOmnivoresp Value(n = 64) (n = 35)BPAQ score (Total)27. 0 ± 31. 436. 3 ± 34. 6p = 0. 032BPAQ score (Current)6. 3 ± 10. 312. 3 ± 15. 7p = 0. 022 BPAQ score (Past)47. 7 ± 63. 060. 3 ± 63. 6p = 0. 047

DISCUSSION

The aim of this study was to investigate if bone health is affected by a vegan diet and varying levels of exercise. Significant differences were discovered between the BUA T-scores of omnivores and vegans, but no significant changes were found with BUA Z-score measurements. Z-scores are the most relevant form of BUA measurement for this particular study as it is better suited for participants under the age of 50 (26). When the Z-scores were divided into low, normal and high categories for vegan and omnivore groups, no significant differences could be found in any of the vegan categories regarding protein, calcium or vitamin D intake, BMI, duration of veganism or BPAQ score. Some trends were evident when observing the means for the data such as decreasing protein and calcium intakes with increasing BUA Z-scores, but due to small sample sizes these could not be considered statistically significant. The omnivore group showed a significant increase in BPAQ scores with increasing BUA Z-scores, but no significant trends could be seen regarding BMI, protein or vitamin D intakes. Interestingly, calcium again showed a negative correlation with Z-scores, but not significantly. A negative correlation between calcium and increasing BUA may appear counter-intuitive but could be explained by the subjects having all underwent puberty, which is the stage of life with the highest demand for calcium. Approximately ~37% of the entire adult skeletal bone mass is accrued during this stage (28). While studies have shown that increasing calcium intake has a beneficial effect on bone mineral density in children (29), no effect has been found when the subject group is between the ages of 20-39 years of age (30, 31), as in this current study. A study by Mazess et al. discovered that calcium intake had no effect on bone mineral density at the

spine, femur or radius, also no longitudinal changes were observed in the spine or radius over 2 years increased calcium intake in 200-300, 20-39 year olds (31). It may therefore be reasonable to suggest that after puberty, increased calcium intake above maintenance would have no effect on bone mineral density and as the lowest calcium intake in the high BUA Z-Score category was still above the levels recommended for that age group, no correlation could really be made with low calcium intakes and high BUA Z-scores. The results of the dietary analysis revealed that vegans consumed significantly more calories, carbohydrates, fat and calcium. A common finding in similar studies has been a lower quantity of calories, protein, calcium and vitamin D in the vegan groups when compared to omnivores (3, 6, 8, 32–34), this can mainly be attributed to a reduced number of calorie or protein dense foods compared to an omnivore diet. Fuhrman and Ferreri (35) gave examples of how vegan athletes can consume high quantities of calories, protein and calcium when required. Although in this current study none of the subjects were professional athletes and the majority of the vegans involved were female and would not have required anymore than ~2, 000 kcal a day. It is reasonable to suggest that the reason for the large difference in calories between the groups (~750 kcal) may have been an issue with the food frequency questionnaire. Several studies have shown that the FFQ is not a reliable measure of estimating macro- or micronutrient intakes (36–41) in a variety of populations. While some studies discovered under-reporting of intakes, others found over-reporting in large populations of subjects using a FFQ, which may explain the unexpectedly high results of this current study. A large review of dietary analysis conducted by Poslusna et al. discovered that over-reporting was found in 40 % of food frequency

questionnaire studies analysed (36). A link was also shown between over-estimation and gender, females demonstrated a higher incidence of overestimation (11. 7%) when compared to males (8. 7%) (36), which could be relevant to this study as the vegan group had a higher ratio of females (75%) when compared to the omnivores (63%). The FFQ has also been shown to specifically over-estimate protein consumption; in a study involving an elderly subject group, actual protein intake measured by 24 hour urine urea excreted was found to be 67% of what the FFQ had indicated (41). Furthermore this study, along with another recent study by Fernandez-Ballart et al discovered that the FFQ is more likely to over-estimate intakes if the questionnaire exceeds 100 items (40), which this study did. This may be due to measurement errors introduced by differing portion size conceptions; misjudgement of how many times an item is consumed in a month or misinterpretation of specific items, especially when one item consists of multiple foods (i. e vegan lasagne).

CONCLUSION

This study found that vegans consume significantly more calories and calcium than omnivores; that protein intake is similar between the two groups and that vitamin D intake is higher in omnivores. The duration of veganism did not show any correlation with bone quality, in fact no effect of diet were found to correlate with changes in bone quality. This study did discover that physical activity was higher in omnivores and increased activity positively correlated with a higher BUA Z-score in omnivores only. Overall no difference between omnivores or vegans could be observed regarding age, sex and race matched bone quality. However this study was limited by a

small sample of subjects and used food frequency measures that have a high degree of potential error associated. Therefore further investigation is needed using larger sample sizes and more accurate measures of dietary intake, i. e. repeated 24 hour intake recall. Words in tables 609 + 35 (refs) = 644