Table 3 Bone turnover marker reference values and established conditions

Type of marker (assay method)	Reference values	Established conditions (women)
Bone formation markers		
BAP (CLEIA)[a]	2.9–14.5 μg/L	Premenopausal
BAP (EIA)[b]	7.9–29.0 U/L	30–44 years
P1NP[c]	17.1–64.7 μg/L	30–44 years
Bone resorption markers		
DPD[b]	2.8–7.6 nmol/mmol Cr	30–44 years
sNTX[b]	7.5–16.5 nmol BCE/L	40–44 years
uNTX[b]	9.3–54.3 nmol BCE/mmol Cr	30–44 years
sCTX[c]	0.100–0.653 ng/mL	30–44 years
uCTX[b]	40.3–301.4 μg/mmol Cr	30–44 years
TRACP-5b[a]	120–420 mU/dL	Young adult mean (YAM 30–44 years)
Bone matrix marker		
ucOC[a]	3.94 ng/mL (not established as reference value)	Upper limit in women ≤44 years
	4.5 ng/mL	Cut-off value for the determination of vitamin K insufficiency (more frequent use in clinical setting)
	5.5 ng/mL	Cut-off value for the risk of fracture

Reference values of bone metabolic markers are within the range of the mean ± 1.96 SD, as established in healthy premenopausal women

Established condition shows the age range for which data was collected

BAP bone alkaline phosphatase, *BCE* bone collagen equivalents, *CLEIA* chemiluminescent enzyme immunoassay, *EIA* enzyme immunoassay, *P1NP* Type 1 procollagen-N-propeptide, *DPD* deoxypyridinoline, *sNTX* and *uNTX* serum and urinary (respectively) Type 1 collagen cross-linked N-telopeptide, *sCTX* and *uCTX* serum and urinary (respectively) Type 1 collagen cross-linked C-telopeptide, *TRACP-5b* tartrate-resistant acid phosphatase 5b, *ucOC* under-carboxylated osteocalcin

[a] Described in kit manufacturer's package insert or manufacturer's in-house data

[b] Described in 2004 guidelines

[c] Article being prepared for submission

Table 4 Bone turnover marker values to consider prompt search for serious bone disease such as metastatic bone tumors or bone/calcium metabolic disorders other than osteoporosis

Type of marker (assay method/sample)	Men	Premenopausal women	Postmenopausal women	Units
Bone formation markers				
BAP (CLEIA)[a]	>20.9	>14.5	>22.6	μg/L
BAP (EIA)[b]	>44.0	>29.0	>75.7	U/L
P1NP[c]	>66.8	>64.7	>79.1	μg/L
Bone resorption markers				
DPD[b]	>5.6	>7.6	>13.1	nmol/mmol Cr
sNTX[b]	>17.7	>16.5	>24.0	nmol BCE/L
uNTX[b]	>66.2	>54.3	>89.0	nmol BCE/mmol Cr
sCTX[c]	>0.845	>0.653	>1.030	ng/mL
uCTX[a]	>299.0	>301.4	>508.5	μg/mmol Cr
TRACP-5b[a]	>590	>420	>760	mU/dL

As a bone metabolic marker in metastatic bone tumors, there is a type I collagen-C-telopeptide (1CTP) assay

With elevated values of bone metabolic markers (≥mean ± 1.96 SD), bone diseases such as metastatic bone tumors, or bone/calcium metabolic disorders such as hyperparathyroidism or hyperthyroidism, should be suspected

Be careful of differences in cut-off values among facilities

BAP bone alkaline phosphatase, *CLEIA* chemiluminescent enzyme immunoassay, *EIA* enzyme immunoassay, *P1NP* Type 1 procollagen-N-propeptide, *DPD* deoxypyridinoline, *sNTX* and *uNTX* serum and urinary (respectively) Type 1 collagen cross-linked N-telopeptide, *sCTX* and *uCTX* serum and urinary (respectively) Type 1 collagen cross-linked C-telopeptide, *TRACP-5b* tartrate-resistant acid phosphatase 5b, *Cr* creatinine, *BCE* bone collagen equivalent

[a] Partially revised from the kit manufacturer's package insert or manufacturer's in-house data

[b] Described in the 2004 guidelines

[c] Described in manufacturer's in-house data and article in preparation for submission

toms, complications, drug contraindications, and previous treatment history. The bone matrix marker, ucOC, reflects vitamin K deficiency, so this information is useful when selecting vitamin K_2 drugs and as an adjunct when evaluating their efficacy (Figs. 2, 3).

Evaluation of drug treatment effects in osteoporosis using bone metabolic markers

Combination of evaluable bone metabolic markers and therapeutic drugs

Using only baseline values of bone metabolic markers it is difficult to predict drug treatment effectiveness. Drug treatment effectiveness can be monitored by repeating the measurement at a given interval after the start of treatment to evaluate changes from baseline values. With drug treatment, only significant changes from baseline values in bone metabolic markers indicate that bone metabolism has changed and the treatment has been effective. In individual patients, the effectiveness of bisphosphonates, SERMs, or estrogen treatment can be assessed using DPD, NTX, CTX, TRACP-5b, BAP, or P1NP. The effectiveness of activated vitamin D_3 (particularly, eldecalcitol) can be assessed using NTX or BAP. The effectiveness of PTH drugs (daily subcutaneous injection) is assessed using P1NP. For other drugs, evaluation by measurement of these bone metabolic markers is not easy. In addition, in treatment using bisphosphonates such as alendronate that have amino groups, changes in urinary free DPD, compared to telopeptides, are known to be smaller [9, 15] (Fig. 4).

One criterion for evaluating treatment effectiveness is whether a change has exceeded the minimum significant change (MSC). The MSC is defined as twice the inter-day variation in the morning in premenopausal women (Table 5). Despite measurement at uniform sample collection times, if no significant changes in bone metabolic markers with drug treatment are observed, patient treatment compliance should first be confirmed. The possibility of another underlying disease causing secondary osteoporosis must also be considered (Table 6). With bisphosphonate therapy, it is also important to check that the time interval between drug administration and meals is sufficient so that there are no problems with drug absorption. If there is no problem with treatment compliance, then the

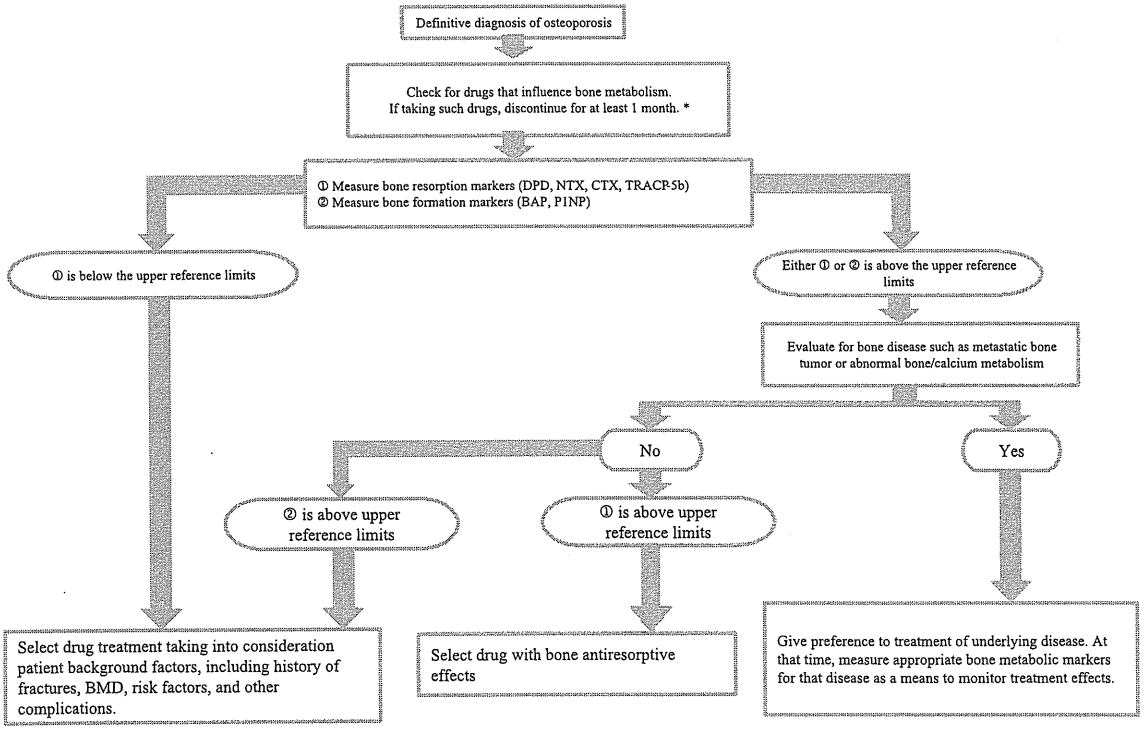

Fig. 2 Measurement of bone resorption markers and bone formation markers when selecting drug treatment for osteoporosis. *Asterisk* for bisphosphonates after stopping for at least 3 months. Bisphosphonates (etidronate disodium, alendronate sodium hydrate, risedronate sodium hydrate, minodronic acid hydrate), SERMs (raloxifene, bazedoxifene), estrogens (estradiol, estriol), calcitonin (elcatonin, salmon calcitonin), and activated vitamin D_3 (eldecalcitol) drugs are known to have bone antiresorptive effects

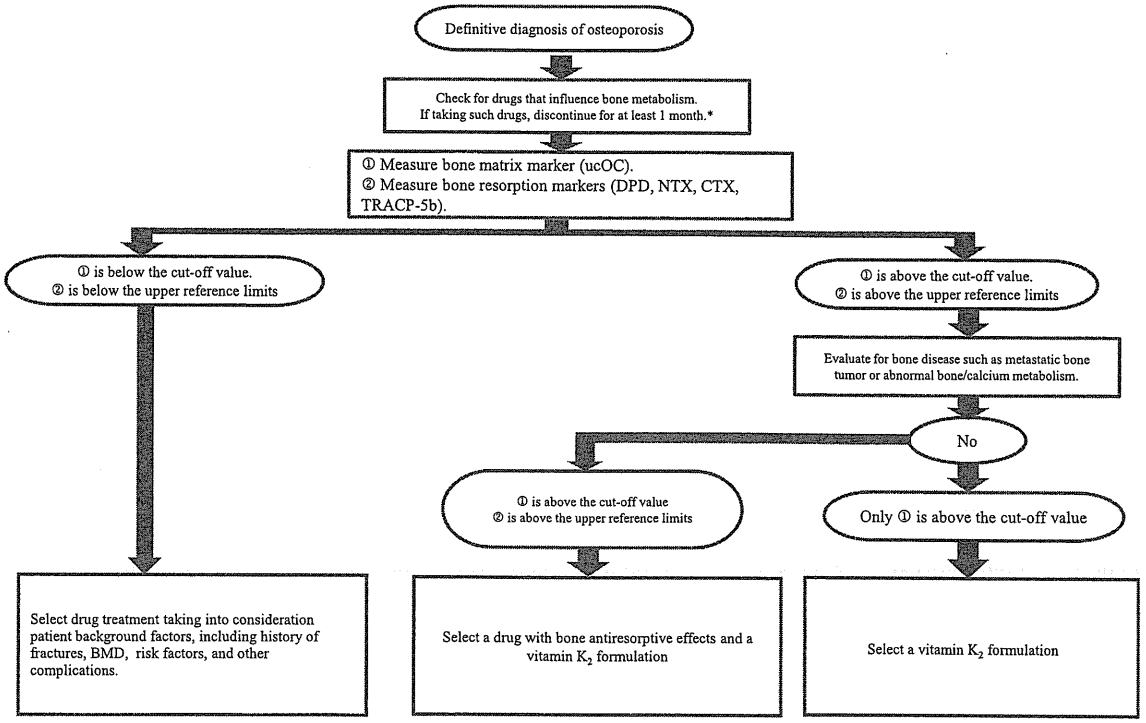

Fig. 3 Measurement of ucOC and bone resorption markers when selecting drug treatment in osteoporosis. *Asterisk* for bisphosphonates after stopping for at least 3 months

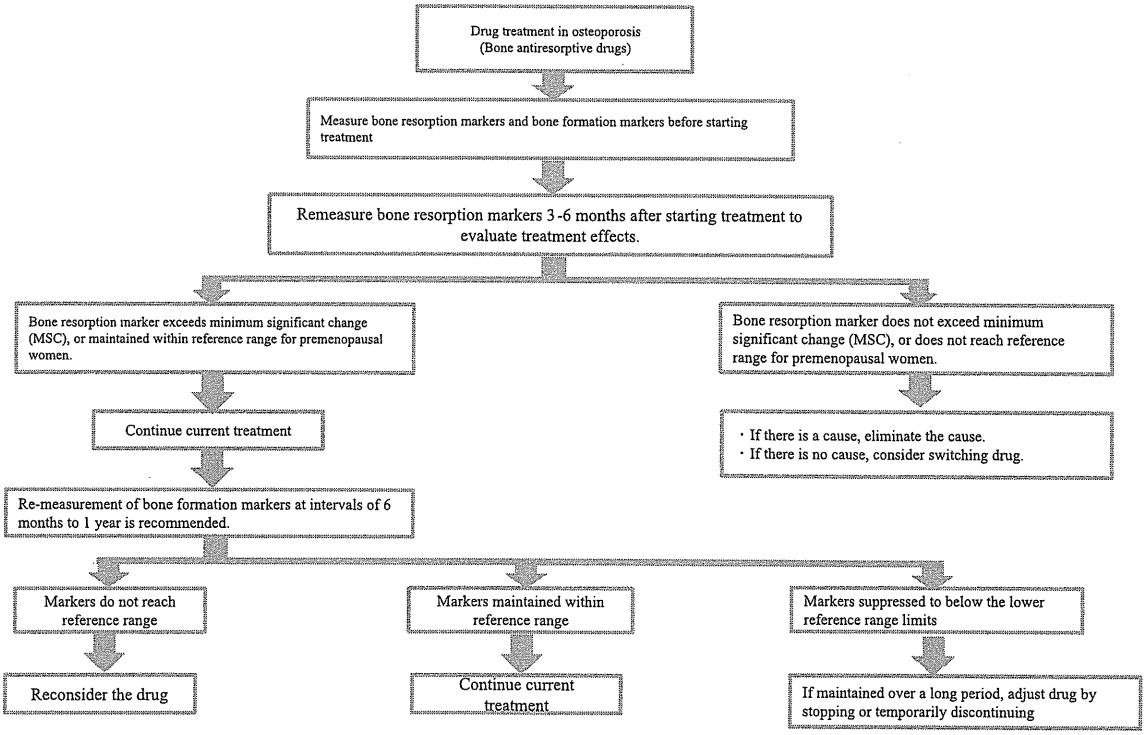

Fig. 4 Evaluation of therapeutic effects of bone antiresorptive drugs using bone resorption markers. Please refer to Table 6

response to drug treatment is inadequate and an increase in dose or switch to another drug is indicated. It should also be kept in mind that depending on the drug administered, there are some drugs for which significant changes in DPD, NTX, CTX, TRACP-5b, BAP, or P1NP are not readily apparent.

Table 5 Minimum significant changes (MSC) in bone turnover markers approved for osteoporosis

Type of marker	Assay method	Units	MSC (%)[a] (twice the mean day-to-day variation)	Reference (%)[b]
Bone formation markers				
BAP	CLEIA	μg/L	9.0	–
BAP	EIA	U/L	–	23.1[c]
P1NP	RIA	μg/L	12.1	–
Bone resorption markers				
DPD[c]	EIA	nmol/mmol Cr	23.5	29.6[c]
sNTX	EIA	Nmol BCE/L	16.3	14.2[c]
uNTX	EIA	nmol BCE/mmol Cr	27.3	35.0 [c]
sCTX	EIA	ng/mL	23.2	–
uCTX	EIA	μg/mmol Cr	23.5	51.1[c]
TRACP-5b	EIA	mU/dL	12.4	16.2[d]
Bone matrix-related marker				
ucOC	ECLIA	ng/mL	32.2	–

BAP bone alkaline phosphatase, *CLEIA* chemiluminescent enzyme immunoassay, *EIA* enzyme immunoassay, *P1NP* Type 1 procollagen-N-propeptide, *RIA* radio immunoassay, *DPD* deoxypyridinoline, *Cr* creatinine, *sNTX* and *uNTX* serum and urinary (respectively) Type 1 collagen cross-linked N-telopeptide, *BCE* bone collagen equivalent, *sCTX* and *uCTX* serum and urinary (respectively) Type 1 collagen cross-linked C-telopeptide, *TRACP-5b* tartrate-resistant acid phosphatase 5b, *ucOC* undercarboxylated osteocalcin

[a] MSC values calculated as twice the day-to-day variations, as requested by committee [basis for establishment: in 10 volunteer premenopausal women, blood and urine samples were collected 5 times during 14 days. These samples were deep-frozen stored until measurement, and measured as batches at a laboratory center (SRL Inc.)]

[b] MSC values are excerpts from the 2004 guidelines and kit package inserts

[c] Described in 2004 guidelines

[d] Described in kit manufacturer's package insert

Table 6 Possible causes for the variation within MSC value in osteoporosis under drug treatment

1. Causes related to various variations
The samples before and after the treatment should be collected at the same time because of the diurnal variation
Measurement errors over a long period of time (e.g., seasonal variation, change in patient status)
Measurement interval is too short
Change in the laboratory performance measurement or change the laboratory site
2. Low compliance of drug and instructions
Inadequate timing with meals (bisphosphonates)
Insufficient medication (low compliance)
3. Current drug for osteoporosis has no effect on bone markers

Appropriate times to measure bone metabolic markers in evaluating treatment effectiveness

The bone resorption markers DPD, NTX, CTX, and TRACP-5b should be measured twice, when treatment is started and 3–6 months after starting treatment, and the percent change should be calculated. With administration of bone antiresorptive drugs, changes in the bone formation markers BAP and P1NP are slightly delayed. For this reason, they should be measured twice—when treatment is started and again at 6 months—and the percent changes should be calculated.

After treatment with bone formation-promoting PTH drugs (recombinant, daily subcutaneous injection), changes in P1NP compared to BAP are more prominent among the bone formation markers. These should be measured twice—when treatment is started and 1–3 months after starting treatment—and the amount/percent of change should be calculated [54, 55]. However, for PTH drugs (weekly subcutaneous injection of teriparatide acetate) administered once a week for 18 months, the bone formation marker osteocalcin (OC) tends to be high throughout the drug administration period, whereas P1NP tends to be high until 3 months, and low from 6 months

onwards. In addition, the bone resorption markers DPD and uNTX are reported to be low after starting treatment, so this should also be considered [56].

Displaying the measurement results

The results of bone metabolic marker measurements can be displayed in two ways for easier interpretation of the changes. The percent changes in response to treatment are calculated and plotted as changes from baseline values [57]. The graph may also include threshold values, which indicate the MSC [57]. In addition, the absolute values can be shown together with reference values obtained from premenopausal women. If the data are displayed in this manner, it is easier to explain to patients.

Future issues

This guideline presents the data, as completely as possible, for current NHI-approved bone formation markers (BAP, P1NP), bone resorption markers (DPD, sNTX/uNTX, sCTX/uCTX, TRACP-5b), and a bone matrix marker (ucOC). Drug therapy for which effectiveness has been evaluated is limited to drugs that have been approved in Japan. The proposals in this guideline (based on examined outcomes) assume primary osteoporosis, and in particular, post-menopausal osteoporosis. Accordingly, whether these can be expanded to apply to secondary osteoporosis due to underlying or drug-induced disease is an issue for further investigation.

Meanwhile, bone metabolic marker changes using *T* scores and scoring, fracture risk, and bone loss (categorical data 2 %/3 years) were each examined. No significant relationship between fracture risk and bone metabolic markers was observed. Similarly, based on the examined categorical data, no relationship to the prediction of bone loss rates was observed. No significance was found in scoring of markers for bone loss prediction. With respect to the evaluation of bone metabolic markers using *T* scores, further studies are needed in a larger number of patients, including evaluation by fracture site for each drug, and evaluation of the relationship between percent decrease in markers and fracture reduction.

In examining the issues leading to these guideline proposals, the measurement of bone metabolic markers was performed at a limited number of laboratory test centers. However, in clinical practice, because bone metabolic markers are measured by multiple laboratory test centers, differences and variations among facilities performing measurements should be recognized and kept in mind. For initially approved bone resorption markers, reagent manufacturers voluntarily perform reagent control studies, and efforts to reduce differences among facilities continue in the direction of further improvement. Some issues that must be resolved in the future include how to differentiate and effectively use bone formation markers and bone resorption markers; establishing optimal levels of bone metabolic markers, not only for assessment of effects; and applying these markers in men and in secondary osteoporosis.

These proposed guidelines for the appropriate use of bone metabolic markers take into consideration current health insurance regulations in Japan. However, in order to achieve a more appropriate use of bone metabolic markers it is now recognized that periodic repeated measurement for monitoring after treatment is also effective. In addition, with bone antiresorptive drugs, particularly bisphosphonates containing amino groups, excessive inhibition of bone metabolism has often been observed and may also be a problem. Keeping target values (optimal levels of absolute values) of bone turnover (based on bone metabolic markers) within the physiologic range of reference values in premenopausal women is also considered important in maintaining bone strength [7, 13]. This issue should also be investigated in Japan by further accumulation of clinical data.

Conflict of interest All authors declare that they have no conflict of interest.

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J Bone Miner Metab
DOI 10.1007/s00774-012-0415-8

ORIGINAL ARTICLE

Consuming breakfast and exercising longer during high school increases bone mineral density in young adult men

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Received: 16 January 2012 / Accepted: 28 November 2012
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Abstract We examined the bone mineral densities (BMDs) of young adult men and analyzed the factors associated with BMD differences. Between 1993 and 2002, all male freshmen in the Wakayama Medical University, Japan were recruited into the present study, which included a self-administrated questionnaire survey, anthropometric measurements, and BMD measurements of the spine and hip. Of a total of 387 freshmen, 382 (98.7 %; mean age, 20.3 years; age range, 18–29 years) completed the study. The mean BMDs of the spine (L2–4) and femoral neck (FN) were 1.21 (standard deviation, 0.13) g/cm^2 and 1.12 (0.14) g/cm^2, respectively. The L2–4 BMDs were not associated with age, while FN BMDs were significantly inversely associated with age. The BMDs at L2–4 and FN were significantly associated with body mass index (BMI). After adjustment for age and BMI, multivariate regression analysis indicated that BMDs at L2–4 and FN were associated with current longer exercise duration (L2–4, $p = 0.024$; FN, $p = 0.001$), those at L2–4 with milk intake ($p = 0.024$), and those at FN with consuming breakfast ($p = 0.004$). Similarly, habits of consuming breakfast and exercising longer (on a weekly basis) during high school were linked with significantly higher L2–4 and FN BMDs. High-impact activities during high school significantly influenced the later BMDs. In conclusion, to maximize peak bone mass, consuming breakfast and completing a longer duration of stronger exercise in the late high school years for at least 10 h per week is recommended.

Keywords Male osteoporosis · Peak bone mass · Breakfast · Exercise · High school

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Published online: 22 December 2012

Introduction

Although osteoporosis (OP) is widely considered to be a disorder that mainly affects women, 13 % of cases of lumbar spine OP and 24 % of cases of femoral neck OP involve men [1]. Up to 20 % of hip fractures occur in men, and the number of men with fractures has been rising in Japan [1, 2]. In addition, several studies have shown higher mortality rates after hip fracture in men than in women [3–6], suggesting that male OP warrants urgent attention.

In studies of male OP, we have reported age-related distributions of BMD in middle-aged and aged residents in a mountainous village [7] and seaside village [8] in Japan. Moreover, we have reported the rate of change of BMDs [9–11], and the prevalence and cumulative incidence of vertebral fractures [12, 13], using data from longitudinal observations of these same populations. However, there have been few studies of male BMD in young adults. In addition, there are few reports regarding environmental factors affecting BMD of young men, despite the fact that peak bone mass is achieved in adolescence.

To prevent osteoporosis and osteoporotic fractures in older men, it is necessary to clarify which lifestyle factors exert the most influence on the BMDs of young men. Therefore, we explored age-related BMD distribution and

associated environmental factors, including diet and exercise, in young medical students.

Materials and methods

Participants

All male freshmen at Wakayama Medical University from 1993 to 2002 were recruited into the study. There were 392 total male freshmen during this time; 382 (97.4 %) completed the study. Excluded subjects included 5 who declined to participate, and 5 older than 30 years. All participants provided written informed consent in advance of participation.

Questionnaire survey regarding lifestyle factors

All participants completed a self-administered questionnaire consisting of 70 items covering medical history including past fractures, injury, diabetes mellitus, renal diseases, gastric diseases, and back pain, medication information, including steroid hormones, oral contraceptive pills, minor tranquilizers, and calcium supplementation, family history of bone fractures, osteoporosis, and back pain, alcohol consumption, smoking status, physical performance, including whether participants can stand in trains or buses, sit down in a chair, sit up on their heels, be active on holidays, sleep on a futon (Japanese-style mattress); sleeping time and toileting style, nutritional habits, and time spent participating in regular sports.

To assess nutritional habits, frequency of consumption (every day, 3–4 times a week, 1–2 times a week, 1–2 times a month, less than once a month) was recorded for food categories such as meat, fish, vegetables, fruits, snacks, beverages, and dairy products. Milk intake frequency (every meal, every day, every week, less than once a week) was recorded for elementary school, junior high school, high school, and the present. Breakfast consumption frequency (every day, sometimes, skipping) was recorded for elementary school, junior high school, high school, and the present.

Exercise time per week ($\geq$10 h per week, 5–10 h per week, 2–5 h per week, 1–2 h per week, <1 h a week) and types of regular sports (walking, gymnastics, golf, cycling, jogging, swimming, other activities specified) was recorded for elementary school, junior high school, high school, and the present.

BMD and anthropometric measurements

Measurements of BMD were made using dual energy X-ray absorptiometry (DXA) (Lunar DPX-1000; GE Lunar, Madison, WI, USA), from antero-posterior images at the lumbar spine (L2–4) and proximal femur (femoral neck (FN), Ward's triangle, and trochanter). In addition, physical parameters such as height, weight, arm span, dominant wrist circumference, and grip strength were measured, and body mass index (BMI; kg/m^2) was calculated. To monitor precision of the DXA apparatus, the equipment was checked at every examination using the same phantom, with BMD of the phantom calibrated to 1.270 $\pm$ 0.025 g/cm^2 (2 %). In addition, all participants were examined by the same medical doctor (N.Y.) so as to control observer variability. Intraobserver variability in DXA in vitro and in vivo had been measured for a prior study by the same medical doctor. Coefficient of variation (CV %) for L2–4 in vitro was 0.35 %, whereas CV % for L2–4, FN, Ward's triangle, and trochanter, examined in vivo in 5 male volunteers, were 0.61–0.90, 1.02–2.57, 1.97–5.45, and 1.77–4.17 %, respectively [14].

Statistical analysis

All statistical analyses were performed using JMP version 8 (SAS Institute Japan, Tokyo, Japan) and STATA (STATA Corp., College Station, Texas, USA). Differences in age, anthropometric measures such as height, weight, body mass index (BMI), and grip power in relation to BMDs were examined by analysis of variance, and differences in alcohol, smoking, and food intake in the present were done using the non-paired Student's t test. The non-paired Student's t test was also used to compare the BMD between groups based on consumption of breakfast, exercise, and milk intake during elementary school to the present. Multiple regression analysis with adjustment by age and BMI was performed to identify factors associated with BMD, with variables chosen according to the results of Student's t test.

Results

Baseline characteristics of all participants, including anthropometric measures, BMDs, and lifestyle factors such as milk intake, consumption of breakfast, and exercise during elementary school, junior high school, high school, and the present are shown in Table 1. During elementary school, 75 % of participants consumed milk every day; however, the prevalence declined through junior high school, high school, and the present. A similar tendency was observed in the habits of consumption of breakfast (including sometimes having breakfast) and longer exercise hours per week.

Figure 1 shows a scatter plot of BMD at L2–4 (Fig. 1a) and FN (Fig. 1b) according to age. L2–4 BMD was not significantly correlated with age ($r = 0.06$, $p = 0.28$),

while FN was negatively correlated with age ($r = -0.10$, $p = 0.043$). None of the participants were diagnosed with osteopenia or OP using the WHO criteria for OP [15].

Table 1 Characteristics of participants

	Total
No.of participants	382
Demographic characteristics	
Age, years	20.3 (2.3)
Height, cm	172.2 (5.3)
Weight, kg	64.4 (9.1)
Body mass index, kg/m^2	21.7 (2.7)
Bone mineral density	
L2–4, g/cm^2	1.21 (0.13)
Femoral neck, g/cm^2	1.12 (0.14)
Ward's triangle, g/cm^2	1.10 (0.20)
Trochanter, g/cm^2	0.95 (0.13)
Life styles	
Elementary school	
Milk intake (every day)	285 (74.8 %)
Consuming breakfast	370 (97.1 %)
Exercise (10 h/week or more)	67 (17.8 %)
Junior high school	
Milk intake (every day)	254 (66.7 %)
Consuming breakfast	358 (94.0 %)
Exercise (10 h/week or more)	174 (45.6 %)
High school	
Milk intake (every day)	211 (55.4 %)
Consuming breakfast	351 (92.1 %)
Exercise (10 h/week or more)	126 (33.0 %)
Present	
Milk intake (every day)	179 (47.0 %)
Consuming breakfast	338 (88.5 %)
Exercise (≥10 h/week or more)	132 (35.1 %)

Except where otherwise indicated, values are the mean (SD)

Analysis of associations between body build and BMD showed that BMD at both L2–4 and FN were significantly correlated with height (L2–4 BMD, $r = 0.26$, $p < 0.0001$; FN BMD, $r = 0.23$, $p < 0.0001$), weight (L2–4 BMD, $r = 0.40$, $p < 0.0001$; FN BMD, $r = 0.31$, $p < 0.0001$), and BMI (L2–4 BMD, $r = 0.32$, $p < 0.0001$; FN BMD, $r = 0.24$, $p < 0.0001$).

Regarding family history and subjects' BMD values, there was no significant association between any of the subjects' mothers or fathers having osteoporosis or fractures and the subjects' BMD values for L2–4 or FN.

Current alcohol consumption, smoking habit, and consumption of other beverages such as yogurt, black tea, green tea, oolong tea, or coffee were not associated with BMDs in the spine or FN, nor were aspects of nutritional intake, such as consumption of meat, fish, vegetables, fruits, snacks, beverages, or dairy products.

For analysis of milk intake, breakfast consumption, and physical activities, participants were divided into groups based on frequency (high and low). High frequency was defined for each parameter as follows: milk intake every day, having breakfast (including sometimes), and exercise ≥10 h in a week. Table 2 compares BMDs between high- and low-frequency groups for each parameter during elementary school, junior high school, high school, and the present. The L2–4 BMD was significantly associated with current high milk intake frequency (vs. less than every day, $p = 0.015$), current breakfast consumption (vs. skipping, $p = 0.038$), and current longer exercise duration (vs. <10 h per week, $p = 0.046$). The FN BMDs were also significantly positively associated with these lifestyle factors.

The associations between BMDs and milk intake, having breakfast, and longer exercise duration in time periods classified as elementary school, junior high school, and high school days are also shown in Table 2. The FN BMDs in the group with daily milk intake in high school were significantly higher than those with less intake group

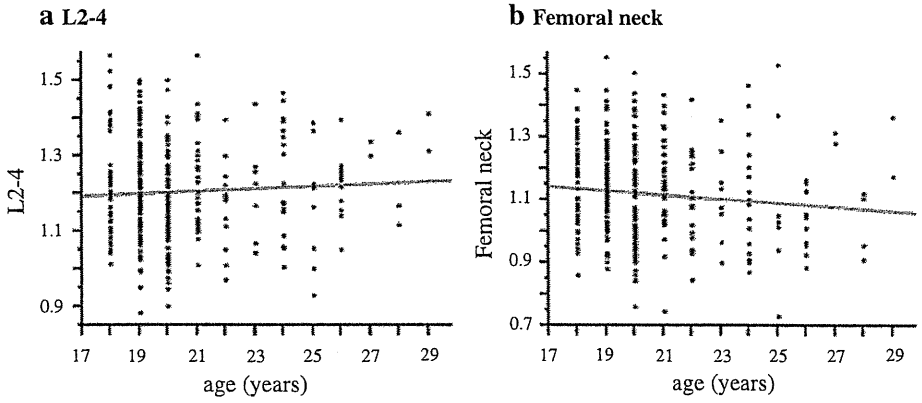

Fig. 1 Association between bone mineral densities and age. **a** Lumbar spine L2–4, **b** Femoral neck

Table 2 Comparison of values of bone mineral density according to frequencies of lifestyle, such as milk intake, consuming breakfast, and total hours for exercise during each period

Milk intake	Elementary school			Junior high school			High school			Present		
	Every day ($N = 285$)	Less ($N = 96$)	p value	Every day ($N = 254$)	Less ($N = 127$)	p value	Every day ($N = 211$)	Less ($N = 170$)	p value	Every day ($N = 179$)	Less ($N = 202$)	p value
L2–4[a]	1.20 (0.13)	1.22 (0.12)	0.41	1.21 (0.13)	1.21 (0.13)	0.98	1.21 (0.13)	1.20 (0.12)	0.25	1.22 (0.14)	1.19 (0.12)	0.015*
Femoral neck[a]	1.12 (0.14)	1.14 (0.13)	0.32	1.13 (0.14)	1.11 (0.14)	0.23	1.14 (0.15)	1.11 (0.13)	0.036*	1.14 (0.15)	1.11 (0.13)	0.034*
Breakfast	Consuming ($N = 370$)	Skipping ($N = 11$)	p value	Consuming ($N = 358$)	Skipping ($N = 23$)	p value	Consuming ($N = 351$)	Skipping ($N = 30$)	p value	Consuming ($N = 338$)	Skipping ($N = 44$)	p value
L2–4[a]	1.21 (0.13)	1.22 (0.11)	0.83	1.21 (0.13)	1.16 (0.13)	0.056	1.21 (0.13)	1.16 (0.12)	0.046*	1.21 (0.13)	1.17 (0.10)	0.038*
Femoral neck[a]	1.13 (0.14)	1.08 (0.18)	0.33	1.13 (0.14)	1.05 (0.18)	0.006	1.13 (0.14)	1.06 (0.15)	0.015*	1.13 (0.14)	1.06 (0.14)	0.002**
Exercise	>10 h/week ($N = 68$)	<10 h/week ($N = 314$)	p value	>10 h/week ($N = 174$)	<10 h/week ($N = 208$)	p value	>10 h/week ($N = 126$)	<10 h/week ($N = 256$)	p value	>10 h/week ($N = 145$)	<10 h/week ($N = 225$)	p value
L2–4[a]	1.21 (0.13)	1.20 (0.11)	0.64	1.22 (0.13)	1.20 (0.13)	0.21	1.23 (0.13)	1.20 (0.13)	0.026*	1.23 (0.14)	1.20 (0.12)	0.046*
Femoral neck[a]	1.12 (0.14)	1.14 (0.15)	0.36	1.12 (0.14)	1.13 (0.14)	0.18	1.16 (0.14)	1.11 (0.14)	0.003**	1.16 (0.14)	1.11 (0.14)	0.001**

Values are the mean (SD)

[a] L2–4, femoral neck mean bone mineral density of L2–4, femoral neck, respectively

N number of subjects

* $p < 0.05$, ** $p < 0.01$

Table 3 Association bewteen bone mineral density and frequencies of lifestyle, such as milk intake, having breakfast, and total hours for exercise during each period after adjustment for age and body mass index

	High school			Present		
	Partial regression coefficients (beta)	p value	Coefficient of determination (R^2)	Partial regression coefficients	p value	Coefficient of determination (R^2)
Milk intake						
L2–4[a]	0.048	0.322	0.108	0.111	0.024*	0.118
Femoral neck[a]	0.088	0.075	0.084	0.081	0.103	0.083
Breakfast						
L2–4[a]	0.097	0.047*	0.115	0.095	0.052	0.114
Femoral neck[a]	0.107	0.031*	0.088	0.142	0.004**	0.096
Exercise						
L2–4[a]	0.122	0.012*	0.120	0.120	0.015*	0.118
Femoral neck[a]	0.175	<0.001***	0.107	0.167	0.001**	0.095

Partial regression coefficients were estimated by multivariate regression analysis after adjusting for age and BMI by bone mineral density at lumbar spine L2–4 or femoral neck as an objective variable and each frequency of milk (every day/less), breakfast (consuming/skipping) and exercise (≥10 h/week/less) during high school as an explanatory variable

[a] L2–4, femoral neck mean bone mineral density of L2–4, femoral neck, respectively

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

($p = 0.04$), while no significant association was found for spinal BMDs with regard to milk consumption. On the other hand, consumption of breakfast in junior high school or high school influenced BMDs. Specifically, BMDs in both L2–4 and FN were higher than those in the breakfast-skipping group (junior high school, L2–4, $p = 0.056$, FN, $p = 0.006$; high school, L2–4, $p = 0.046$, FN, $p = 0.015$). In addition, longer exercise duration (≥10 h a week) in high school was associated with higher BMDs in spine and FN (L2–4, $p = 0.026$, FN, $p = 0.003$).

To clarify the association between BMD values and frequencies of lifestyle factors such as milk intake, breakfast consumption, and total hours of exercise during high school and currently, multiple regression analysis was performed using BMD values at lumbar L2–4 or FN as an objective variable and each frequency of milk consumption (every day or less), breakfast (consuming/skipping), and exercise (≥10 h/week or less) during high school and currently, after adjustment for age and BMI (Table 3). Table 3 shows the partial regression coefficients (β), p values, and coefficients of determination (R^2) of the model. After adjustment for age and BMI, the association between spinal BMDs and milk intake or exercise remained significant (milk intake, $p = 0.024$; longer exercise, $p = 0.015$), while the association between spinal BMDs and breakfast consumption reduced ($p = 0.052$). The FN BMDs remained significantly associated with breakfast consumption and longer exercise duration (having breakfast, $p = 0.004$; longer exercise, $p = 0.001$), while association with milk intake reduced ($p = 0.103$).

The association between breakfast consumption during high school and BMDs at both L2–4 and FN remained significant (L2–4, $p = 0.047$; FN, $p = 0.031$) after adjustment for age and BMI (Table 3). Similarly, BMDs at both L2–4 and FN and exercise ≥10 h a week during high school were significantly associated (L2–4, $p = 0.012$; FN, $p < 0.001$), while the association between BMDs at spine and FN and milk intake during high school was no longer significant (L2–4, $p = 0.322$; FN, $p = 0.075$).

Discussion

In the present study, we found mean BMDs at L2–4 and FN in young adult men to be 1.21 and 1.12 g/cm^2, respectively, and that FN BMDs significantly decreased according to age in the 18–29 years age group. Further, we explored whether breakfast consumption and longer exercise, especially during the high school period, could positively influence BMD.

Peak bone mass is a key determinant of skeletal health throughout life. In both men and women, the consensus view holds that bone mass increases substantially during the first 20 years before reaching a plateau. However, the timing of the plateau is still controversial. Some studies reported peak bone mass as early as 20 years [16, 17]. Baxter-Jones et al. [18] reported that peak bone mass in their cohort of male and female adolescents occurred by the end of the second decade or very early in the third decade. In the present study, BMD values of L2–4 were not significantly correlated with age ($r = 0.06$, $p = 0.28$), but those of FN were negatively correlated with age ($r = -0.10$, $p = 0.043$). Our results suggest that the peak bone mass at the FN of Japanese young men might be reached

before 20 years of age and then decrease; however, we could not determine the BMD changes in this cross-sectional study. We intend to clarify the bone changes in young men and women in the follow-up study in the subjects of the present study and determine whether the BMD values would increase or decrease in their 20s.

There are few reports about the relationships between diet and BMD in men, especially in young adult men. Hirota et al. [19] reported that annual increases in quantitative ultrasound bone status in boys aged 10–15 years was associated positively with increased height and weight, increased intake of small fish and vegetables, intake of dairy products, and awareness of bone measurement. In addition, several experimental studies have shown that calcium supplementation increases BMDs in children and adolescents [20–23]. In several Western countries, specific dietary intake of calcium has been recommended for children and adolescents to maximize peak bone mass [24]. In the present study, among young men aged 18–29 years, daily milk intake during high school days and currently was associated with higher BMDs. Although this association was reduced after adjusting for age and BMI, the association between spinal BMD and milk intake remained significant. Therefore, even in male subjects aged 18–29 years of age, milk intake would effectively increase BMD.

Various positive effects of consuming breakfast on nutrition and body build have been reported [25, 26]. Deshmukh-Taskar et al. [25] reported that breakfast consumers had more favorable intake of nutrients including calcium, fiber, and various micronutrients, than breakfast skippers, in a study of children aged 9–13 years ($N = 4{,}320$) and adolescents aged 14–18 years ($N = 5{,}339$). In addition, they found that prevalence of obesity (body mass index $\geq$95th percentile) was higher in breakfast skippers. Larson et al. [26] demonstrated that eating breakfast improved total daily calcium intake in a study of 4,079 middle and high school students. However, little is known about the relationship between consuming breakfast and BMD in young men and women. In an initial survey similar to the present study and performed in 1993, examining 63 medical students (48 men, 15 women) in the first grade of the Wakayama Medical University, we reported that BMD was the highest in the group who had regularly had breakfast in every period (elementary school, junior high school, high school, and the present) followed by the group who had sometimes eaten breakfast, and then by the group who had rarely eaten breakfast [27]. The results of the present study supported those of the previous study. We then concluded that a habit of consuming breakfast, in junior high school and high school, can effectively maintain maximum peak bone mass.

Several reports [28–30] have demonstrated a contribution of exercise or physical activities to bone mass in male adolescents. Babaroutsi et al. [28] reported that bone mass in subjects who spent at least some of their weekly time on physical activities tended towards higher calcaneal bone mass measured with quantitative ultrasound than in non-exercisers, among healthy Greek males in 3 age groups (children, adults, and elderly). Välimäki et al. [29] performed heel ultrasound measurement, DXA, and muscle strength tests in 196 army recruits and 50 control men, aged 18–20 years, and found that exercise is the most important determinant of ultrasonographic characteristics. They showed that physical loading during military training increases bone speed of sounds (SOS). Delvaux et al. [30] investigated the contribution of youth physical activity to the development of adult bone mass in a prospective population study over 27 years and concluded that lifetime physical activity, as well as physical fitness and BMI, contributed to adult bone mass. In the present study, we found that regular exercise $\geq$10 h per week during high school, while not significant in junior high school or elementary school, was significantly associated with higher BMDs at both L2–4 and FN. We then concluded that to maximize peak bone mass, longer exercise duration at the latest in the high school period, at least 10 h per week, is recommended.

As mentioned above, we determined when and after how long do subjects participating in regular sports start to maintain high BMD. Another question then arose: What type of sports should be performed? To clarify the association between BMD and exercise type, we analysed the sport types during the subjects' high school days and found that they fell into a wide range, including gymnastics, athletics, wrestling, weightlifting, mountain climbing, tennis, soft tennis, rugby, soccer, handball, volleyball, baseball, softball, judo, aikido, karate, kyudo (Japanese art of archery), kendo (Japanese fencing), fencing, table tennis, boat, dancing, cycling, and swimming. According to recreational physical activity classification [31], we divided the participants into 4 groups: a high-impact sports group (tennis, jogging, football, rugby, volleyball, basketball); moderate-impact sports group (golf, table tennis, dancing); low-impact sports group (floor exercise, sailing, boating, cycling for pleasure); and a no-impact group (swimming, fishing, snooker, no sports). Multivariate regression analysis using BMD values at lumbar spine L2–4 or FN as an objective variable and classification of impact of sports as an explanatory variable after adjustment for age and BMI indicated that compared to no-impact activity, high-, moderate-, and mild-impact exercise during high school were significantly strongly associated with BMDs at lumbar spine L2–4 and FN, respectively (L2–4 vs. no-impact activity: high, $\beta = 0.21$, $p < 0.001$; moderate, $\beta = 0.15$, $p = 0.003$; mild, $\beta = 0.08$, $p = 0.087$, $R^2 = 0.154$; FN vs. no-impact activity: high, $\beta = 0.27$, $p < 0.001$; moderate,

$\beta = 0.08$, $p = 0.110$; mild, $\beta = 0.07$, $p = 0.136$, $R^2 = 0.143$). Therefore, we concluded that, to maximize peak bone mass, in addition to longer exercise duration (at least 10 h/week) in the high school period, stronger exercise is recommended.

There are several limitations in the present study. Most notably, our sample size is relatively small, and our sample may not be strongly representative of young Japanese men, although the participation rate for potential candidates was nearly 100 %. However, the values of anthropometric factors of the participants in the present study were not significantly different from those of the general population obtained from the report of the 2002 National Health and Nutrition Survey conducted by the Ministry of Health, Labour and Welfare, Japan [32] (values of BMI (SD), 22.1 (3.1) of men in the age groups of 20s in the National Health and Nutrition Survey, 21.7 (2.7) in the present study). So, it seems that any selection bias in the present study did not cause the sample to deviate significantly from the general Japanese population in the same age range. Second, as an index of bone mass, we used BMD values in the present study. During growth, bone mineral content (BMC) may be a more precise index of bone mass than BMD since most of the components of bone accumulation at the growing stage are associated with changes in bone size. However, subjects in the present study were all young medical students with a mean age of 20.3 years (age range, 18–29 years), and we regarded the growth of bone size as completed, so we used the BMD values instead of BMC values. Third, imperfect memory during the questionnaire survey, especially when recalling past lifestyle factors, might give rise to memory bias. Although such problems are difficult to avoid in a questionnaire survey, the average age of our study participants was 20.3 years, an age at which memory is generally good, and no participants complained that they could not recall lifestyle factors from their younger ages during the questionnaire survey. Therefore, we believe that the results of the present study accurately reflect past lifestyles to a large extent. Fourth, our study is an aggregate of annual cross-sectional studies of male freshmen from 1993 to 2002; hence, there might be a cohort effect in the sample. Thus, the characteristics of the 1993 study may differ from those in 2002. To determine whether there are differences among subjects who participated each year, we compared the anthropometric factors across years. There were no significant differences in BMI among subjects classified by year of participation. Therefore, we concluded that consuming breakfast and exercising during high school were significant factors for higher BMD in male adolescents through the 10 annual studies. Finally, we could not estimate the amount of nutrients such as vitamin D or K that might influence bone mass because we did not use a questionnaire that could translate the frequency of food intake into nutrients, such as a self-administered diet history questionnaire (DHS). To elucidate the importance of having breakfast on maintaining bone health in the present study, we intend to perform a detailed nutrition survey using the DHS.

In conclusion, lifestyle habits such as breakfast consumption and longer exercise duration during high school exerted positive influences on BMD in young Japanese men. Such habits are likely to affect skeletal health as men age.

Acknowledgments This work was supported by the following Grants-in-Aid for Scientific Research: B20390182 (Noriko Yoshimura), Collaborating Research with NSF 08033011-00262 (Director, Noriko Yoshimura) from the Ministry of Education, Culture, Sports, Science and Technology; H17-Men-eki-009 (Director, Kozo Nakamura), H18-Choujyu-037 (Director, Toshitaka Nakamura), and H20-Choujyu-009 (Director, Noriko Yoshimura) from the Ministry of Health, Labour and Welfare in Japan. This study was also supported by grants from the Japan Osteoporosis Society (Noriko Yoshimura) and Nakatomi Foundation (Noriko Yoshimura). The sponsors had no role in the study design, data collection, data analysis, data interpretation, or writing of this report.

Conflict of interest The authors have no conflicts/disclosures to declare.

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Mod Rheumatol
DOI 10.1007/s10165-012-0824-5

ORIGINAL ARTICLE

Associations between neck and shoulder discomfort (Katakori) and job demand, job control, and worksite support

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Received: 24 May 2012 / Accepted: 18 December 2012
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Abstract
Objectives To examine the association of neck and shoulder discomfort (Katakori) with somatization and work-related factors (job demand, job control, and worksite support) in Japanese workers.
Methods Cross-sectional data from 2,022 Japanese workers were analyzed using a logistic regression model to examine the association between Katakori and somatization. A multiple logistic regression model was used to examine the association between Katakori and work-related factors (long working hours, job control, and support from colleagues and supervisors) after adjusting for possible confounding factors.
Results The odds of Katakori were higher among respondents with somatic symptoms than among those without (OR = 2.81 and 95 % CI 2.10–3.75 for 1 symptom vs. no symptoms; OR = 3.86 and 95 % CI 2.92–5.12 for 2+ symptoms vs. no symptoms). Lack of worksite support was significantly associated with Katakori (adjusted OR = 2.62; 95 % CI 1.79–3.83). Long working hours and a lack of job control were not significantly associated with Katakori.
Conclusions Katakori may be a form of somatization. A significant association was observed between Katakori and lack of worksite support from colleagues or supervisors. An increase in the social support provided at work may decrease the prevalence of this condition and improve workers' well-being, but more research is needed to substantiate this hypothesis.

Keywords Nonspecific neck pain · Psychosocial factors · Somatization · Worksite support

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Published online: 22 January 2013

Introduction

Neck and shoulder discomfort, or *Katakori* is a common complaint among Japanese adults. Katakori is defined as discomfort or dull pain caused by muscle stiffness around the back of the head and through the shoulders and/or shoulder blades [1]. There is no English term with the precise meaning of "Katakori," but "neck and shoulder pain," "nonspecific neck pain," and "trapezius myalgia" appear to refer to similar symptoms [2–4]. Katakori is a major somatic complaint in the general Japanese population [5] and may be associated with health-related quality of life (QOL) [6]. Therefore, Katakori is a relevant health matter in Japan.

Katakori can occur as a primary complaint, without any associated diseases, or secondary to another disease or condition. The diseases noted for causing secondary Katakori are cervical spine diseases, glenohumeral joint diseases, cardiovascular diseases, pulmonary diseases, eye fatigue, temporomandibular arthrosis, and menopausal

syndrome. The actual prevalence of Katakori secondary to these diseases is not known.

Although the cause of primary Katakori is not fully known, it has been proposed that hemodynamics in the trapezius muscle might be involved [7]. Eriksen hypothesized that head-down and neck flexion positions and/or psychological stress increase the intracellular nitric oxide/oxygen ratio through sympathetic nerve activity, resulting in inhibition of cytochrome oxidase. Lactate production would follow, activating nociceptive fibers [8]. However, evidence regarding the mechanism underlying Katakori is scarce.

Several factors may be associated with Katakori. Women are thought to be more susceptible than men, although few studies have reported these findings [9]. A high prevalence of Katakori has been reported among visual display terminal (VDT) workers. Sixty-nine percent of VDT workers have reported physical tiredness or complaints, and 75 % of them reported having Katakori [10]. Work-related psychosocial factors may also be associated with Katakori. Work-related factors (job demand, job control, availability of support from colleagues or supervisors at the worksite, job satisfaction), along with somatization and other psychosocial factors, have been studied as predictors of back pain outcome [11]. Perceived stress and subjective job demand have been reported to be associated with Katakori [1, 6, 12]. However, few studies have examined the association between Katakori and work-related factors such as job demands, level of job control, and support at the worksite.

Katakori may also be associated with somatization. Some people suffer persistent physical complaints that cannot be fully explained by pathological changes. Somatizing individuals experience or express emotional discomfort and psychosocial distress as physical symptoms [13]. The possible association of Katakori with psychological stress suggests that this condition is a physical expression of somatization.

The purpose of this study is to examine whether Katakori is associated with somatization and whether job demand, level of job control, and worksite support are associated with Katakori in Japanese workers.

Subjects and methods

Subjects

This study is part of a multicenter international study called the Cultural and Psychosocial Influence on Disability (CUPID) study. The CUPID study focuses on regional pain and associated disability in workers and has been carried out in 19 countries [14]. The subjects from Japan included nurses, office workers, sales and marketing personnel, and transportation workers who were employed in Tokyo. The nurses were employed at a university hospital in Tokyo. Office workers in administrative and clerical jobs were employed at the same hospital, one of four pharmaceutical companies, or a private trading company. Sales and marketing personnel were employed at one of six pharmaceutical companies, and the transportation workers (mainly lorry drivers and loaders) were employed at one of two companies that transported baggage and mail. Within each participating organization, a manager distributed a self-administered questionnaire with a cover letter from the survey team to all employees in relevant jobs. A total of 3,187 questionnaires were distributed to 1,074 nurses, 425 office workers, 380 sales/marketing personnel, and 1,308 transportation workers. Subjects were excluded from the analysis if they had worked in their current job for less than 1 year, because this study focused on the association between work-related factors and Katakori. Subjects were also excluded from the analysis if any information regarding outcome variables, potential associating factors, or covariates was missing.

Assessment

The questionnaire consisted of a Japanese translation of the original CUPID study items and newly designed questions regarding Katakori. The questionnaire assessed demographic characteristics, smoking habits, physical exercise, duration of employment in the current job, working hours per week, level of job control, worksite support, and comorbidities, including arthritis, spinal diseases (disc hernia, discopathy, spondylosis, spinal stenosis), and subjective malocclusion of the teeth (a misalignment of teeth or incorrect relation between the upper and lower teeth). Body mass index (BMI, kg/m^2) was calculated using self-reported weight and height. Overweight was defined as BMI $\geq$ 25. Regular exercise was defined as physical exercise performed more than twice a week for 20 min or longer during the previous 12 months.

High job demand was defined as working 60 h or more per week. To assess the level of job control, respondents were asked, "In your job, do you have a choice in deciding how you do your work, what you do at work, and your work timetable and breaks?" These items had four response options: often, sometimes, seldom, and never/almost never. A low degree of job control was defined as the combination of "seldom" or "never/almost never" for all three items related to job control. To assess the level of worksite support, respondents were asked, "When you have difficulties in your work, how often do you get help and support from your colleagues or supervisor/manager?" This item had five response options: often, sometimes,

seldom, never, and not applicable. Low worksite support was defined as an answer of "seldom" or "never" for worksite support. The questionnaire also contained items to assess mental health and somatization. Mental health was assessed using relevant items from the MOS 36-item short-form health survey (SF-36) ver. 1.2 [15, 16]. Depression was defined as having a score of 52 or lower on the SF-36 ver. 1.2 mental health summary; the score of 52 is the cut-off value for Japanese adults [17]. Somatization was assessed using a subset of items from the Brief Symptom Inventory [18]. The Japanese version of the Brief Symptom Inventory somatization scale was linguistically validated [19]. Seven somatic symptoms (faintness or dizziness, pains in the heart or chest, nausea or upset stomach, trouble breathing, numbness or tingling in parts of the body, feeling weak in parts of the body, and hot or cold spells) were assessed on a 5-point scale (0, not at all; 1, a little bit; 2, moderate; 3, quite a bit; and 4, extreme). Respondents were also asked whether they conducted any of the following activities during an average workday: use of a keyboard or typewriter for more than 4 h in total (VDT work), working longer than 1 h in total with their hands above shoulder height (work with hands above the shoulder), or driving for 4 h or longer (driving).

Katakori was defined as discomfort or dull pain caused by muscle stiffness around the back of the head and extending through the shoulders and/or shoulder blades. Respondents were asked about the frequency and severity of Katakori they had experienced during the previous month. The frequency of Katakori was assessed on a 6-point scale (1, always; 2, almost always; 3, often; 4, sometimes; 5, seldom; 6, never). The severity of Katakori was measured on an 11-point numerical rating scale (NRS) ranging from 0 (no Katakori) to 10 (the worst possible).

Statistical analysis

Initially, a simple descriptive analysis was performed. The characteristics of respondents with severe Katakori were compared to those without severe Katakori using the χ^2 test. An individual with severe Katakori was defined as a person who experienced Katakori categorized as "always," "almost always," or "often," with a severity of 7 or higher on the NRS.

The association between severe Katakori and somatization was assessed by simple logistic regression. Somatization was classified into three categories (0, 1, and 2+) based on the number of somatic symptoms (7 total) scored as "moderate," "quite a bit," or "extreme" [17]. The odds ratios, 95 % confidence intervals (CIs), and *P* values for having severe Katakori were calculated.

A multiple logistic regression model was used to examine whether job demand, job control, and worksite support were associated with severe Katakori in more detail. The covariates were age, sex, current smoking habit, overweight, regular exercise, VDT work, work with the hands above shoulder height, driving, depression, arthritis/spinal diseases, and malocclusion.

The adjusted odds ratio (aOR), 95 % CI, and *P* value for severe Katakori were calculated. Statistical analysis was conducted using SAS 9.2 (SAS Institute Inc., Cary, NC). All statistical tests were two-tailed, and a significance level of 0.05 was used.

The study protocol was reviewed and approved by the ethics committees of the University of Tokyo Hospital. All participants provided written informed consent.

Results

Questionnaires were returned by 2,651 (83 %) of the workers, but 285 were excluded from analysis because the individuals who filled them out had been in their current jobs for less than 1 year. An additional 76 workers were excluded due to missing information regarding age (52), sex (1), or both (23). An additional 268 were excluded due to missing information related to Katakori, work hours, job control, worksite support, somatization, or covariates. A total of 2,022 subjects (63 %) was analyzed in the present study.

The mean age of these 2,022 respondents was 36.8 (standard deviation = 9.2, range 19–61) years; 1,383 (68.4 %) of the subjects were men. The prevalence of severe Katakori was 19.0 % (men 10.8 %; women 36.9 %). The characteristics of the respondents are summarized in Table 1. Of the 2,022 respondents, 26 % were nurses, 14 % were office workers, 17 % were sales/marketing personnel, and 44 % were transportation operatives. Over 40 % of workers worked 60 h or longer per week. Nineteen percent of respondents had low job control, and 10 % received little worksite support from their colleagues and/or superiors.

The characteristics of respondents with and without severe Katakori are shown in Table 2. Among those with severe Katakori compared to those without, fewer respondents worked 60 h or longer per week, and more respondents had low job control and/or low worksite support. Respondents with severe Katakori were more frequently women, nurses, VDT workers, ex-smokers and nonsmokers, and individuals who did not engage in regular exercise, did not drive long hours, suffered from depression, and had somatic symptoms.

The association between severe Katakori and somatization is shown in Table 3. The odds of severe Katakori among respondents with somatic symptoms were significantly higher than in respondents without somatic

Table 1 Characteristics of respondents (n = 2,022)

	n (%)
Severe neck and shoulder discomfort (Katakori)	385 (19.0)
Male	1,383 (68.4)
Age (years)	
<30	527 (26.1)
30–39	804 (39.8)
40–49	464 (23.0)
≥50	227 (11.2)
Job	
Nurse	515 (25.5)
Office worker	288 (14.2)
Sales/marketing	334 (16.5)
Transportation	885 (43.8)
Current smoker	865 (42.8)
Overweight (BMI ≥ 25)	286 (14.1)
Regular exercise +	375 (18.6)
VDT ≥ 4 h/day	489 (24.2)
Work with hands above shoulder ≥ 1 h/day	386 (19.1)
Driving ≥ 4 h/day	607 (30.0)
Depression (SF36 ≤ 52)	647 (32.0)
Somatization	
0	1,418 (70.1)
1	307 (15.2)
2+	297 (14.7)
Arthritis/spinal disease	60 (3.0)
Malocclusion	370 (18.3)
High work demand (work ≥ 60 h/week)	875 (43.3)
Low job control	391 (19.3)
Low worksite support	197 (9.7)

VDT visual display terminal, *BMI* body mass index

symptoms, and the odds increased with more symptoms (OR = 2.81 and 95 % CI 2.10–3.75 for 1 symptom; OR = 3.86 and 95 % CI 2.92–5.12 for 2+ symptoms).

The results of multiple logistic regression analysis are shown in Table 4. After adjusting for covariates, low worksite support was significantly associated with severe Katakori (aOR = 2.62; 95 % CI 1.79–3.83). Job demand (in terms of working hours or job control) was not significantly associated with severe Katakori.

Discussion

The association between work-related factors and workers' well-being has been studied extensively in the field of occupational health. The association between job strain and issues related to worker health, such as cardiovascular disease and mortality, has been examined using hypothetical models to investigate various job characteristics. In the demand–control model, Karasek [20] focused on two factors: work load demand and job control (decision latitude). He termed the combination of a high-demand job with low job control as a "high strain job" and hypothesized that this combination leads to adverse health outcomes [20]. Johnson and Hall [21] expanded this model to develop the "demand–control–support model" by considering social support by co-workers. These models suggest that job control and worksite support can reduce the association between job demand and adverse effects on workers' physical and psychological health. Demerouti and Bakkar [22, 23] extended these concepts further to develop the job demands–resources model. According to this model, job demands refer to physical, psychological, social, and organizational aspects of the job that are demanding, such as a high level of work pressure, an unfavorable physical environment, or emotionally demanding interactions with clients. Job resources include autonomy, social support, performance feedback, and task significance. Many studies have examined the impact of job characteristics on workers' well-being using these models. The association between low back pain outcomes and work-related psychosocial factors has been studied in western countries as well. Factors such as heavy physical work demands, poor relationships with colleagues, job satisfaction, and work status have been reported to be associated with back pain outcomes [24–26].

In the present study, a lack of support from colleagues and/or supervisors was associated with severe Katakori even after adjustment for other relevant variables such as sex, VDT work, working with the hands above shoulder height, and mental health. Kimura et al. [6] reported an association between the Perceived Stress Scale score and the subjective severity of Katakori. Yabuki [1] studied Japanese female nurses and reported that compared to nurses without Katakori, more nurses with Katakori thought their job involved hard labor. We found that employees with severe Katakori reported higher work demand and more fatigue than those without this condition [27]. These findings suggest that stress and/or job strain is associated with Katakori, and the results of the present study are in line with these previous observations. In addition, the size of the effect (aOR) of worksite support was relatively large. Although causation cannot be inferred and the causal mechanism is not clear, psychological stress caused by a lack of support at the worksite might play a role in the occurrence of Katakori. Worksite support is modifiable. Strengthening worksite support might help decrease the incidence of Katakori among employees, which could benefit employers by improving worker productivity.

A significant association between severe Katakori and somatization was also found in the present study. Previous studies have reported that emotional stress and

Table 2 Comparison of characteristics between respondents with and without severe neck and shoulder discomfort (Katakori) (n = 2,022)

	Total n = 2,022	Without severe Katakori n = 1,383	Severe Katakori n = 639	P value[a]
Male, n (%)	1,383 (68.4)	1,234 (75.4)	149 (38.7)	<0.001
Age (years), n (%)				
<30	527 (26.1)	416 (25.4)	111 (28.8)	0.21
30–39	804 (39.8)	649 (39.7)	155 (40.3)	
40–49	464 (23.0)	378 (23.1)	86 (22.3)	
≥50	227 (11.2)	194 (11.9)	33 (8.6)	
Job, n (%)				
Nurse	515 (25.5)	329 (20.1)	186 (48.3)	<0.001
Office worker	288 (14.2)	223 (13.6)	65 (16.9)	
Sales/marketing	334 (16.5)	290 (17.7)	44 (11.4)	
Transportation	885 (43.8)	795 (48.6)	90 (23.4)	
Current smoker, n (%)	865 (42.8)	759 (46.4)	106 (27.5)	<0.001
Overweight (BMI ≥ 25), n (%)	286 (14.1)	235 (14.4)	51 (13.3)	0.57
Regular exercise +, n (%)	375 (18.6)	326 (19.9)	49 (12.7)	0.001
VDT ≥ 4 h/day, n (%)	489 (24.2)	371 (22.7)	118 (30.7)	0.001
Work with hands above shoulder ≥1 h/day, n (%)	386 (19.1)	319 (19.5)	67 (17.4)	0.35
Driving ≥ 4 h/day, n (%)	607 (30.0)	537 (32.8)	70 (18.2)	<0.001
Depression (SF36 ≤ 52), n (%)	647 (32.0)	487 (29.8)	160 (41.6)	<0.001
Somatization, n (%)				
0	1,418 (70.1)	1,233 (75.3)	185 (48.1)	<0.001
1	307 (15.2)	216 (13.2)	91 (23.6)	
2+	297 (14.7)	188 (11.5)	109 (28.3)	
Arthritis/spinal disease, n (%)	60 (3.0)	44 (2.7)	16 (4.2)	0.13
Malocclusion, n (%)	370 (18.3)	292 (17.8)	78 (20.3)	0.27
High work demand (work ≥ 60 h/week), n (%)	875 (43.3)	748 (45.7)	127 (33.0)	<0.001
Low job control, n (%)	391 (19.3)	305 (18.6)	86 (22.3)	0.10
Low worksite support, n (%)	197 (9.7)	142 (8.7)	55 (14.3)	0.001

VDT visual display terminal, *BMI* body mass index

[a] P value of the χ^2 test

Table 3 Logistic regression analysis of the association between severe neck and shoulder discomfort (Katakori) and somatization (n = 2,022)

Somatization	Odds ratio	95 % CI		P value
0	1.00			
1	2.81	2.10	3.75	<0.001
2+	3.86	2.92	5.12	<0.001

psychologically stressful tasks are associated with increased electromyographic activity in the trapezius muscle [28, 29]. Increased muscular tension in the trapezius might play a role in the development of Katakori. Conflicting results have been reported on the association between objective muscle stiffness and subjective Katakori severity [1, 6]. Somatizing patients convert psychological or social distress into somatic symptoms, and somatization is predictive of musculoskeletal disease or disability [11, 13]. The results of the present study thus suggest that somatization after exposure to psychological stress (e.g., a lack of supervisor support) may play a role in the development of Katakori. Additionally, Katakori may be partly regarded as a symptom of somatization that can be triggered by psychologic stress such as lack of support from supervisors.

Surprisingly, our results indicate that VDT work and malocclusion are not significantly associated with severe Katakori. In general, these variables have been thought to be associated with Katakori [10, 30]. Lack of regular exercise and depression were significantly associated with severe Katakori in the present study. Multiple factors related to VDT work, including ergonomic, psychosocial, and organizational factors, may play roles in the musculoskeletal symptoms associated with VDT work [28]. Therefore, the self-reported duration of VDT work that we measured may not explain Katakori by itself; other factors