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Special report

Diagnostic criteria of primary osteoporosis

The Committee of the Japanese Society for Bone and Mineral Research for Development of Diagnostic Criteria of Osteoporosis
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Introduction

Historically speaking, the diagnosis of primary osteoporosis was performed mainly by radiographic methods [1–3]. Recently, bone mineral density (BMD) measurement has become available and in 1994, the World Health Organization (WHO) proposed new diagnostic criteria of this disease based on the BMD values [4]. Because the BMD values used in the WHO diagnostic criteria were obtained from Caucasian women, the problem remained whether the same diagnostic criteria apply to Japanese women.

Therefore, in 1995, the Japanese Society for Bone and Mineral Research established a committee for developing diagnostic criteria based on the BMD data of Japanese women. Members of the committee consist of an internist, orthopedic surgeons, gynecologist, radiologist, pediatrician, and biostatistician interested in osteoporosis. New diagnostic criteria were proposed as a consensus made by the committee at the end of 1995. In 1996, various problems in the 1995 criteria were reviewed by the committee and the final version was established.

Definition of osteoporosis

Osteoporosis is defined as a pathological condition associated with low bone mass and altered fine structure of the bone tissue that makes the bones fragile and susceptible to fracture [5]. Two major types of osteoporosis, primary and secondary osteoporosis, are recognized.

Basic concept for establishing diagnostic criteria of primary osteoporosis

The diagnosis is made on the basis of bone mineral density (BMD) and lateral X-ray films of the spine. The reasons why we selected BMD and lateral X-ray films of the spine as indices for osteoporosis diagnosis are as follows: first, the X-ray is essential for evaluating spine fracture; second, it may be useful for evaluating bone mass where BMD measurement is not available; and third, it may be useful for making differential diagnosis.

1. In cases whose BMD (spine, radius, second metacarpal bone, femoral neck, or calcaneus) is less than 70% of young adult mean (YAM) or in cases with vertebral fracture(s) and whose BMD is less than 80% of YAM, differential diagnosis should be performed to rule out secondary osteoporosis (Figs. 1, 2) and other diseases associated with low bone mass (Table 1).
2. Evaluation of low bone mass may be made by BMD measurement or by X-ray films of the spine. The criterion of radiographic osteopenia proposed by the research group on osteoporosis, Ministry of Health and Welfare, may be helpful. These are as follows Fig. 3:
   Grade I: the longitudinal trabeculae are prominent
   Grade II: the longitudinal trabeculae are coarse
   Grade III: the longitudinal trabeculae are unclear

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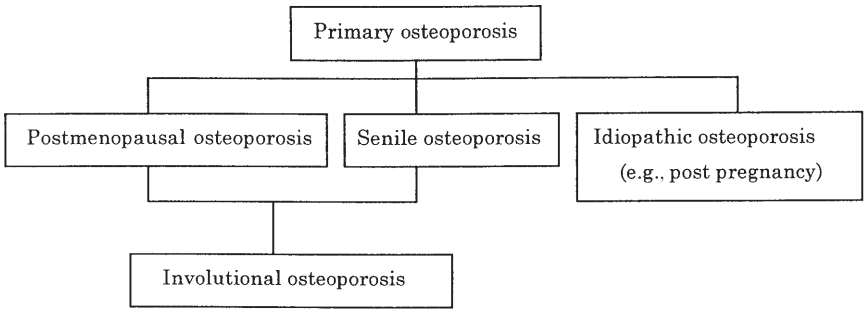

Fig. 1. Classification of primary osteoporosis

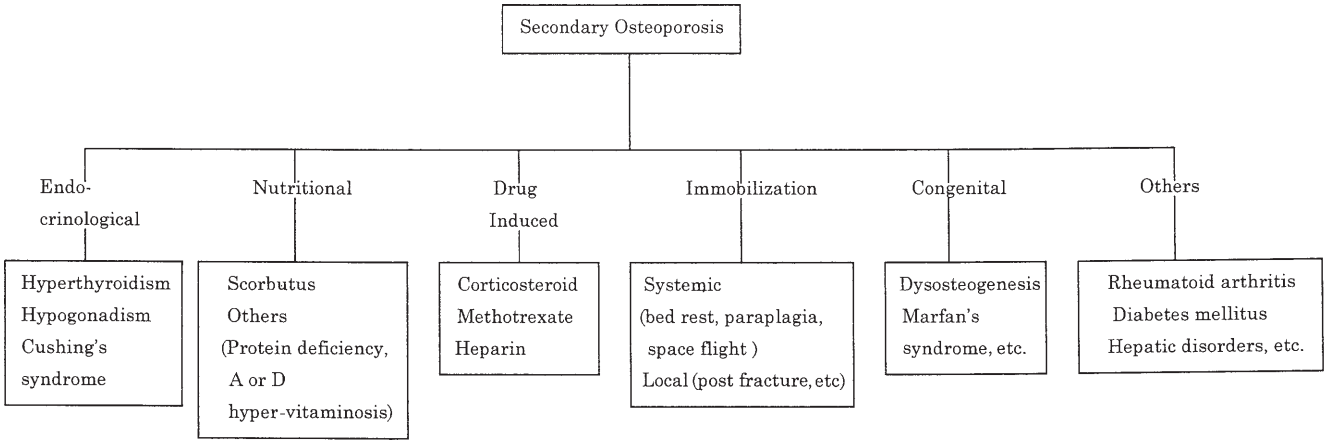

Fig. 2. Classification of secondary osteoporosis

Table 1. Diseases to be differentiated from primary osteoporosis

1. Secondary osteoporosis
2. Other diseases with reduced bone mass
   - i. Osteomalacia
   - ii. Primary, secondary hyperparathyroidism
   - iii. Bone metastasis of malignant tumor
   - iv. Multiple myeloma
   - v. Spinal hemangioma
   - vi. Spinal caries
   - vii. Purulent spondylitis
   - viii. Others

3. The presence or absence of spine fracture should be checked by the lateral X-ray films of the thoracolumbar spine according to the criteria described here. As shown in Fig. 4, if either C/A or C/P is less than 0.8, or A/P is less than 0.75, the presence of spine fracture is confirmed [6,7].
4. The cutoff values of BMD was set at 70% below YAM for the following reasons. The young adult mean (YAM) of BMD implies the average values of BMD in women between 20 and 44 years old. If the cutoff value is set at 70% below YAM, subjects with spine fracture can be efficiently discriminated in terms of specificity and sensitivity from those without spine fracture. If the cutoff value of BMD is set at 2.5 SD below YAM (WHO criteria), the actual cutoff value is different depending upon the site where BMD is measured. As shown in Table 2, the prevalence of osteoporosis diagnosed by WHO criteria was proved to be different depending upon the site of BMD measured. On the contrary, if the cutoff value was expressed in percent, a single value at 70% below YAM can be applied to spine, radius, second metacarpal bone, femoral neck, and calcaneus. Another advantage is that expression in percent is much easier to understand than that in SD for both physicians and patients.
5. The diagnosis of primary osteoporosis is made using the diagnostic criteria only after performing differential diagnosis. Therefore, the diagnosis of primary osteoporosis is made by exclusion.

Diagnostic criteria of primary osteoporosis in women

The proposal was made that the diagnosis of primary osteoporosis should be made according to the diagnostic manual of primary osteoporosis (Fig. 5) using the diagnostic criteria shown in Table 3.

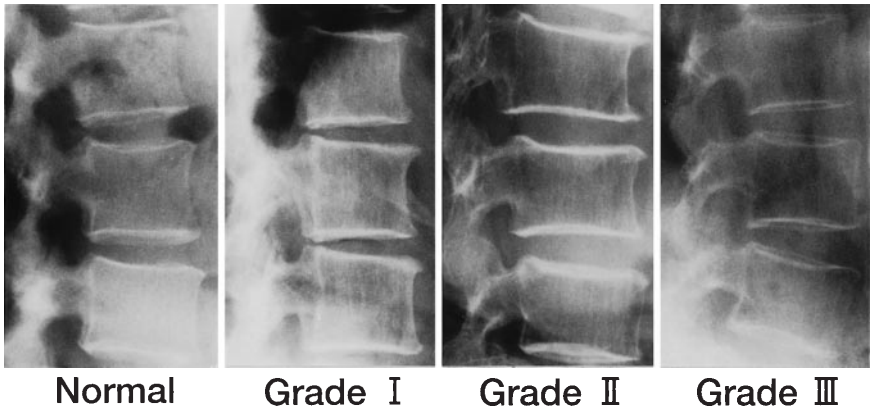

Fig. 3. Criteria for determination of reduced bone mass on vertebral X-ray film

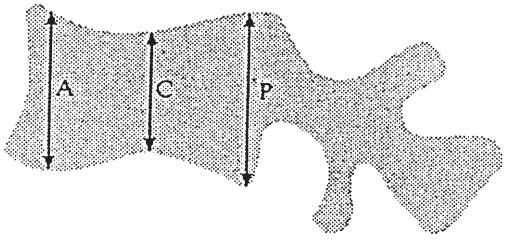

Fig. 4. Schematic diagram of determination of vertebral fracture

Table 2. Prevalence of osteoporosis in women more than 50 years old as diagnosed by WHO criteria

Site	Method	Prevalence (%)
Lumbar spine	DXA	24.4
Hip	DXA	10.9
Radius, one-third	DXA	52.2
Calcaneus	SXA	34.1
Metacarpal	CXD	36.9

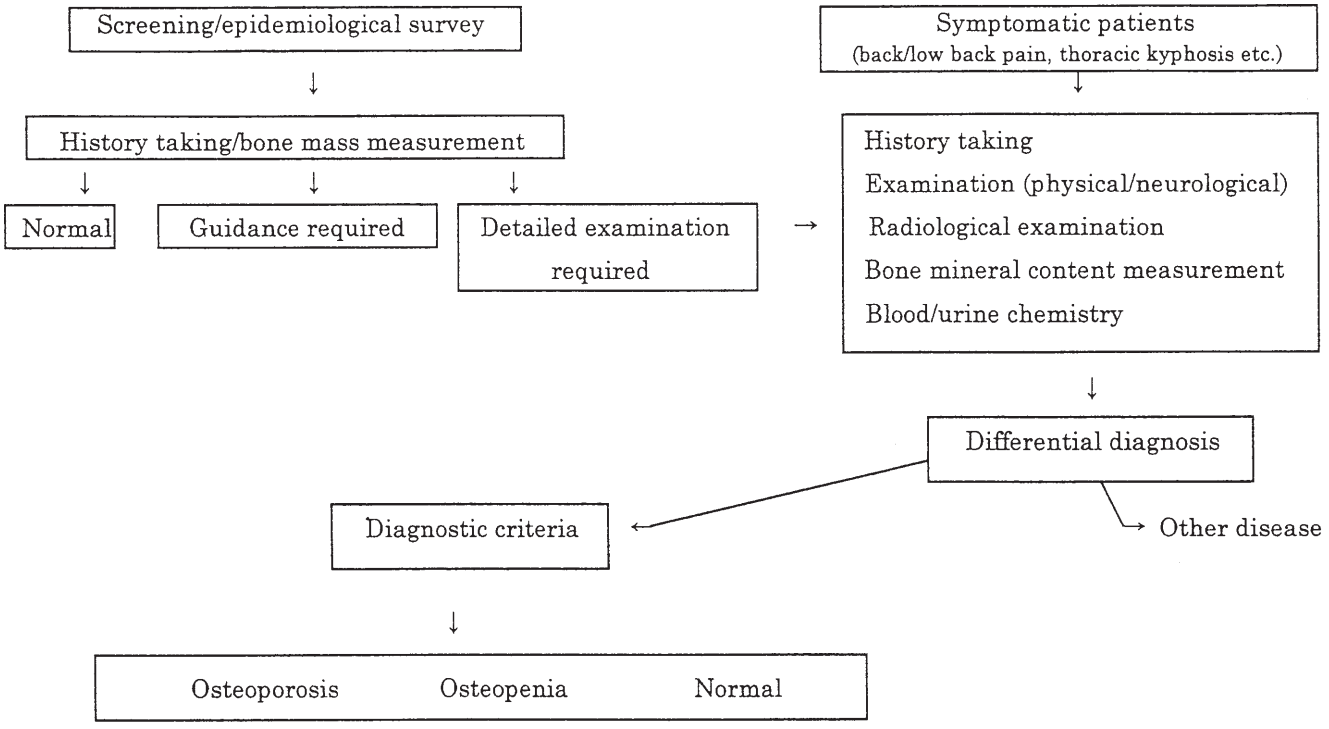

Fig. 5. Diagnostic manual of primary osteoporosis

Studies and discussion

Determination of reference values of BMD for lumbar spine, radius, second metacarpal bone, femoral neck, and calcaneus

Values of BMD were determined for each site of the skeleton measured by each type of apparatus where more than 5000 cases were available. The methods and apparatus for BMD measurement were as follows: BMD for lumbar spine by DXA (QDR; Hologic, DPX; Lunar, XR; Norland and 1X; Hitachi), BMD for radius by DXA (DCS-600; Aloka, pDXA; Norland/Stratec and DTX-200; Osteometer), BMD for second metacarpal bone by microdensitometric method (CXD; Teijin and DIP; Hamamatsu Photonics) [8,9], BMD for femoral neck by DXA (QDR; Hologic, DPX; Lunar, XR; Norland); and BMD for calcaneus by DXA (Heelscan DX-2000; KDR). The reference values are summarized in Tables 4–17.

Determination of cutoff values for BMD of lumbar spine, radius, second metacarpal bone, femoral neck, and calcaneus

The cutoff values were defined as the value by which the subjects with spine fracture were discriminated from those without spine fracture efficiently in terms of sensitivity and specificity. Retrospective studies were conducted at six regions (a–f) in Japan from October 1993 to November 1996. The subjects and measurement sites were as follows:

a. Number of subjects: 245 (132 with vertebral fracture; 113 without vertebral fracture)

Table 3. Diagnostic criteria of primary osteoporosis (revised in 1996)

I. Cases with vertebral fracture on X-ray film
Cases with reduced bone mass (grade I or more severe radiographic osteopenia, or BMD less than 80% of young adult mean [YAM]) and with nontraumatic vertebral fracture should be diagnosed as having osteoporosis.

II. Cases without vertebral fracture on X-ray film

	X-ray film of spine	Lumbar BMD
Normal	No radiographic osteopenia	
Osteopenia	Grade I radiographic osteopenia	70%–80% of YAM
Osteoporosis	Grade II or more severe radiographic osteopenia	Less than 70% of YAM

YAM, young adult mean (20–40 years old)
Note: In principle, BMD means bone mineral density of lumbar spine, but if lumbar BMD is difficult to assess, that of the radius, second metacarpal bone, femoral neck, or calcaneus may be used

Table 4. Female: reference value of bone mineral density (BMD) of lumbar spine (QDR)

Age (years)	*n*	BMD (g/cm^2)	%change
20–24	197	1.004 ± 0.105	99.3
25–29	93	1.003 ± 0.110	99.2
30–34	94	1.029 ± 0.113	101.8
35–39	161	1.016 ± 0.121	100.5
40–44	544	1.010 ± 0.125	99.9
45–49	1082	0.993 ± 0.139	98.2
50–54	2018	0.925 ± 0.148	91.4
55–59	2170	0.842 ± 0.139	83.2
60–64	2242	0.795 ± 0.137	78.6
65–69	1744	0.771 ± 0.146	76.3
70–74	1094	0.743 ± 0.158	73.5
75–79	606	0.714 ± 0.152	70.6
80–84	282	0.694 ± 0.176	68.7
85–	92	0.688 ± 0.134	68.0
Total:	12419		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

Table 5. Female: reference value of bone mineral density (BMD) of lumbar spine (DPX)

Age (years)	*n*	BMD (g/cm^2)	%change
20–24	32	1.171 ± 0.113	98.3
25–29	50	1.172 ± 0.129	98.3
30–34	77	1.184 ± 0.141	99.4
35–39	208	1.190 ± 0.142	99.9
40–44	449	1.198 ± 0.152	100.5
45–49	754	1.164 ± 0.156	97.7
50–54	1169	1.065 ± 0.170	89.4
55–59	1092	0.974 ± 0.165	81.7
60–64	1031	0.915 ± 0.159	76.8
65–69	834	0.913 ± 0.183	76.6
70–74	429	0.870 ± 0.177	73.0
75–79	151	0.840 ± 0.189	70.4
80–84	50	0.580 ± 0.171	71.3
85–89	18	0.813 ± 0.205	68.2
Total:	6344		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

Table 6. Female: reference value of bone mineral density (BMD) of lumbar spine (XR)

Age (years)	*n*	BMD (g/cm^2)	%change
20–24	299	1.036 ± 0.141	99.7
25–29	202	1.029 ± 0.120	98.9
30–34	160	1.047 ± 0.140	100.7
35–39	232	1.062 ± 0.127	102.1
40–44	420	1.032 ± 0.142	99.3
45–49	796	1.019 ± 0.159	98.1
50–54	1073	0.942 ± 0.160	90.6
55–59	884	0.865 ± 0.160	83.2
60–64	693	0.813 ± 0.149	78.2
65–69	483	0.770 ± 0.156	74.0
70–74	327	0.730 ± 0.143	70.3
75–79	203	0.726 ± 0.171	68.0
80–84	51	0.664 ± 0.170	63.8
85–	18	0.813 ± 0.205	68.2
Total:	5915		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

Table 7. Female: reference value of bone mineral density (BMD) of lumbar spine (1X)

Age (years)	*n*	BMD (g/cm^2)	%change
20–24	65	1.058 ± 0.103	97.7
25–29	128	1.063 ± 0.118	98.1
30–34	343	1.082 ± 0.117	99.8
35–39	628	1.090 ± 0.132	100.6
40–44	638	1.084 ± 0.135	100.1
45–49	1163	1.054 ± 0.138	97.3
50–54	1151	0.972 ± 0.145	89.7
55–59	1015	0.883 ± 0.140	81.5
60–64	794	0.848 ± 0.136	78.3
65–69	198	0.842 ± 0.137	77.7
70–74	91	0.831 ± 0.140	76.7
75–79	33	0.795 ± 0.162	73.4
80–84	19	0.750 ± 0.147	69.2
85–	14	0.714 ± 0.131	65.9
Total:	6280		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

Table 8. Female: reference value of bone mineral density (BMD) of radius (DCS-600)

Age (years)	*n*	BMD (g/cm^2)	%change
20–24	105	0.659 ± 0.054	101.9
25–29	90	0.656 ± 0.047	101.4
30–34	137	0.654 ± 0.053	101.3
35–39	272	0.646 ± 0.055	100.0
40–44	429	0.639 ± 0.050	98.8
45–49	771	0.636 ± 0.055	98.4
50–54	1241	0.605 ± 0.066	93.6
55–59	1812	0.550 ± 0.077	85.1
60–64	2373	0.513 ± 0.076	79.3
65–69	2124	0.487 ± 0.076	75.3
70–74	1114	0.461 ± 0.077	71.3
75–79	417	0.430 ± 0.078	66.5
80–84	126	0.406 ± 0.077	62.9
85–	24	0.386 ± 0.089	59.8
Total:	11035		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

Table 9. Female: reference value of bone mineral density (BMD) of radius (XCT-960)

Age (years)	*n*	BMD (mg/cm^3)	%change
20–24	257	393.7 ± 64.9	97.1
25–29	205	398.9 ± 60.4	98.4
30–34	202	407.8 ± 57.9	100.6
35–39	249	407.6 ± 62.5	100.5
40–44	385	413.9 ± 60.3	102.1
45–49	617	415.6 ± 66.0	102.5
50–54	814	386.6 ± 67.0	95.4
55–59	744	350.3 ± 62.5	86.4
60–64	589	318.6 ± 59.6	78.6
65–69	442	300.2 ± 59.6	74.1
70–74	369	291.6 ± 56.1	71.9
75–79	248	276.1 ± 57.6	68.1
80–84	118	266.2 ± 49.0	65.7
85–89	36	237.2 ± 54.7	58.5
Total:	5275		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

Age of subjects (mean ± SD): fracture group, 65.9 ± 7.2 years; nonfracture group, 59.2 ± 6.7 years
Measured sites (type of machine): lumbar spine (QDR), radius (DSX-600), and femoral neck (QDR)

b. Number of subjects: 395 (123 with vertebral fracture; 272 without vertebral fracture)
Age of subjects (mean ± SD): fracture group, 73.5 ± 7.9 years; nonfracture group, 65.8 ± 8.9 years
Measured sites (type of machine): lumbar spine (DPX), second metacarpal bone (CXD), and femoral neck (DPX)

c. Number of subjects: 177 (52 with vertebral fracture; 125 without vertebral fracture)
Age of subjects (mean ± SD): fracture group, 62.5 ± 12.4 years; nonfracture group, 59.8 ± 8.0 years
Measured sites (type of machine): lumbar spine (XR)

d. Number of subjects: 629 (248 with vertebral fracture; 381 without vertebral fracture)
Age of subjects (mean ± SD): fracture group, 74.0 ± 8.3 years; nonfracture group, 62.6 ± 11.6 years
Measured sites (type of machine): radius (DCS-600)

Table 10. Female: reference value of bone mineral density (BMD) of radius (pDXA)

Age (years)	*n*	BMD (g/cm^2)	%change
20–24	146	0.756 ± 0.065	100.5
25–29	173	0.760 ± 0.059	101.0
30–34	162	0.764 ± 0.065	101.5
35–39	162	0.758 ± 0.063	100.7
40–44	435	0.742 ± 0.070	98.6
45–49	748	0.717 ± 0.068	95.3
50–54	831	0.679 ± 0.082	90.2
55–59	803	0.616 ± 0.095	81.8
60–64	725	0.575 ± 0.094	76.4
65–69	676	0.536 ± 0.097	71.2
70–74	624	0.501 ± 0.096	66.5
75–79	444	0.463 ± 0.091	61.5
80–84	242	0.446 ± 0.098	59.3
85–	142	0.405 ± 0.086	53.8
Total:	6313		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

Table 11. Female: reference value of bone mineral density (BMD) of radius (DTX-200)

Age (years)	*n*	BMD (g/cm^2)	%change
20–24	300	0.467 ± 0.054	98.1
25–29	425	0.463 ± 0.052	97.3
30–34	403	0.475 ± 0.052	99.9
35–39	671	0.481 ± 0.055	101.1
40–44	1040	0.481 ± 0.054	101.0
45–49	998	0.479 ± 0.054	100.7
50–54	971	0.457 ± 0.061	96.0
55–59	939	0.411 ± 0.066	86.3
60–64	722	0.378 ± 0.066	79.4
65–69	350	0.357 ± 0.066	75.0
70–74	196	0.334 ± 0.075	70.1
75–79	145	0.314 ± 0.064	66.0
80–84	65	0.295 ± 0.078	61.9
85–	29	0.302 ± 0.090	63.5
Total:	7254		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

Table 12. Female: reference value of bone mineral density (BMD) of second metacarpal bone (CXD)

Age (years)	*n*	BMD (mmAl)	%change
20–24	236	2.692 ± 0.274	98.2
25–29	83	2.724 ± 0.221	99.4
30–34	228	2.764 ± 0.226	100.8
35–39	454	2.762 ± 0.220	100.8
40–44	1139	2.739 ± 0.228	99.9
45–49	1808	2.734 ± 0.230	99.7
50–54	2290	2.605 ± 0.264	95.0
55–59	2533	2.385 ± 0.273	87.0
60–64	2676	2.264 ± 0.260	82.6
65–69	1971	2.172 ± 0.265	79.2
70–74	980	2.074 ± 0.281	75.7
75–79	445	1.949 ± 0.288	71.1
80–84	373	1.780 ± 0.283	65.0
85–	296	1.640 ± 0.266	59.8
Total:	15512		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

Table 13. Female: reference value of bone mineral density (BMD) of second metacarpal bone (DIP)

Age (years)	*n*	BMD (mmAl)	%change
20–24	2252	2.788 ± 0.240	97.4
25–29	3192	2.854 ± 0.242	99.6
30–34	5653	2.877 ± 0.241	100.5
35–39	7032	2.880 ± 0.247	100.5
40–44	7263	2.867 ± 0.250	100.1
45–49	9163	2.835 ± 0.258	99.0
50–54	8382	2.705 ± 0.289	94.4
55–59	8190	2.502 ± 0.294	87.3
60–64	7337	2.375 ± 0.288	82.9
65–69	5854	2.272 ± 0.286	79.3
70–74	2688	2.172 ± 0.289	75.8
75–79	952	2.073 ± 0.310	72.4
80–84	223	1.975 ± 0.279	69.0
85–	43	1.847 ± 0.253	64.5
Total:	68224		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

e. Number of subjects: 196 (40 with vertebral fracture; 156 without vertebral fracture)
Age of subjects (mean ± SD): fracture group, 70.3 ± 9.6 years; nonfracture group, 58.2 ± 10.9 years
Measured sites (type of machine); radius (XCT-960)

f. Number of subjects: 131 (71 with vertebral fracture; 60 without vertebral fracture)
Age of subjects (mean ± SD): fracture group, 70.1 ± 9.8 years; nonfracture group, 50.3 ± 9.3 years
Measured sites (type of machine): femoral neck (XR)

Cases from the foregoing regions a and b have some missing data.

Figures 6–14 show the results of the analysis. For data of the radius (DCS-600), cases from the a and b regions were pooled and analyzed together. The cutoff values are often set at the point where the sensitivity curve intersects the specificity curve. However, in the present study, the cutoff values were determined from the standpoint that they should be comprehensively determined taking into account the variation among the subjects, the relationship between sensitivity and specificity, and assessment at other sites.

Table 14. Female: reference value of bone mineral density (BMD) of femoral neck (QDR)

Age (years)	*n*	BMD (g/cm^2)	%change
20–24	60	0.803 ± 0.089	105.2
25–29	28	0.748 ± 0.131	98.0
30–34	45	0.755 ± 0.102	99.0
35–39	78	0.769 ± 0.112	100.8
40–44	170	0.751 ± 0.111	98.4
45–49	458	0.757 ± 0.113	99.2
50–54	701	0.721 ± 0.111	94.4
55–59	846	0.654 ± 0.098	85.7
60–64	935	0.619 ± 0.095	81.1
65–69	1037	0.601 ± 0.092	78.8
70–74	624	0.570 ± 0.088	74.6
75–79	390	0.542 ± 0.084	71.0
80–84	192	0.511 ± 0.089	66.9
85–	63	0.473 ± 0.091	62.0
Total:	5627		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

Table 15. Female: reference value of bone mineral density (BMD) of femoral neck (DPX)

Age (years)	*n*	BMD (g/cm^2)	%change
20–24	26	0.990 ± 0.117	108.2
25–29	4	0.971 ± 0.187	106.2
30–34	13	0.924 ± 0.112	101.1
35–39	30	0.894 ± 0.141	97.8
40–44	519	0.911 ± 0.116	99.6
45–49	834	0.905 ± 0.124	99.0
50–54	1189	0.856 ± 0.120	93.6
55–59	969	0.793 ± 0.119	86.8
60–64	803	0.746 ± 0.098	81.5
65–69	426	0.723 ± 0.106	79.1
70–74	141	0.684 ± 0.101	74.8
75–79	62	0.650 ± 0.090	71.0
80–84	32	0.587 ± 0.122	64.2
85–	14	0.511 ± 0.145	55.9
Total:	5062		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

Table 16. Female: reference value of bone mineral density (BMD) of femoral neck (XR)

Age (years)	*n*	BMD (g/cm^2)	%change
20–24	181	0.822 ± 0.125	102.4
25–29	158	0.822 ± 0.130	102.4
30–34	158	0.770 ± 0.124	95.9
35–39	263	0.793 ± 0.123	98.8
40–44	548	0.805 ± 0.132	100.3
45–49	1041	0.808 ± 0.129	100.7
50–54	1363	0.753 ± 0.128	93.8
55–59	1313	0.686 ± 0.115	85.5
60–64	1146	0.642 ± 0.104	80.0
65–69	1218	0.608 ± 0.107	75.8
70–74	1060	0.583 ± 0.107	72.6
75–79	800	0.547 ± 0.099	68.2
80–84	434	0.508 ± 0.096	63.3
85–	159	0.471 ± 0.101	58.7
Total:	9842		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

Table 17. Female: reference value of bone mineral density (BMD) of calcaneus (Heelscan DX-2000)

Age (years)	*n*	BMD (g/cm^2)	%change
20–24	346	0.845 ± 0.085	100.4
25–29	439	0.840 ± 0.081	99.8
30–34	415	0.842 ± 0.087	100.0
35–39	342	0.840 ± 0.077	99.8
40–44	396	0.843 ± 0.080	100.1
45–49	677	0.829 ± 0.086	98.5
50–54	721	0.794 ± 0.089	94.3
55–59	663	0.749 ± 0.088	89.0
60–64	415	0.703 ± 0.096	83.5
65–69	369	0.680 ± 0.081	80.8
70–74	357	0.636 ± 0.091	75.5
75–79	261	0.617 ± 0.090	73.3
80–84	159	0.573 ± 0.086	68.1
85–	72	0.558 ± 0.090	66.3
Total:	5632		

Note: BMD values are given as mean ± SD; for %change, YAM is 100%

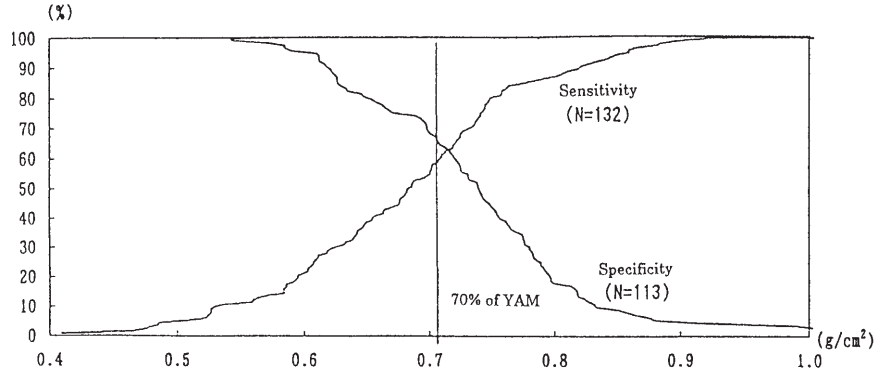

Fig. 6. Female: cutoff values of BMD of lumbar spine (QDR)

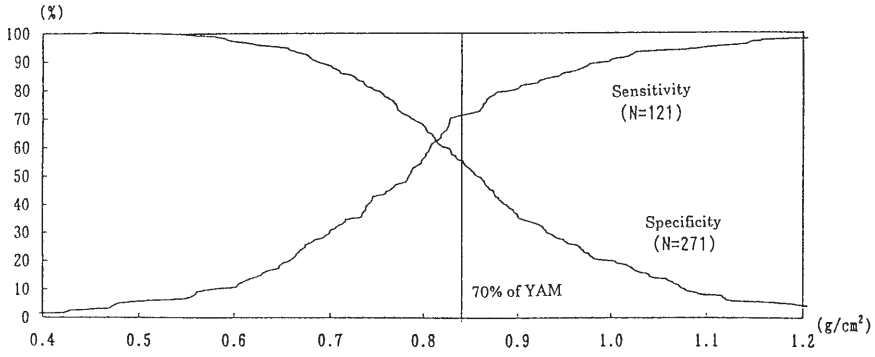

Fig. 7. Female: cutoff values of BMD of lumbar spine (DPX)

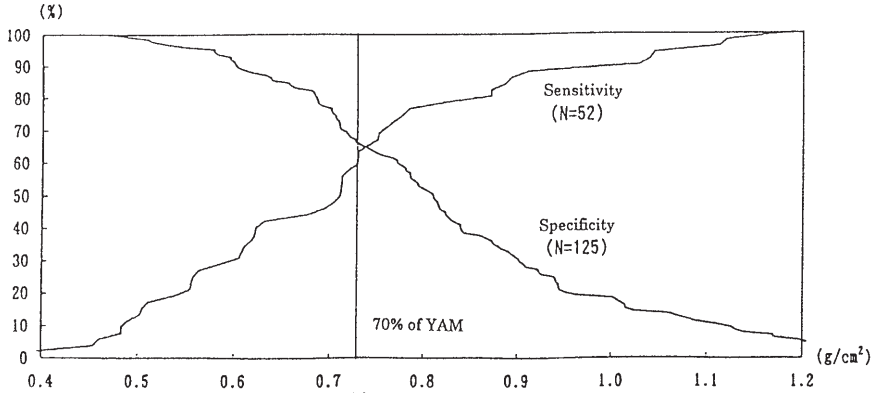

Fig. 8. Female: cutoff values of BMD of lumbar spine (XR)

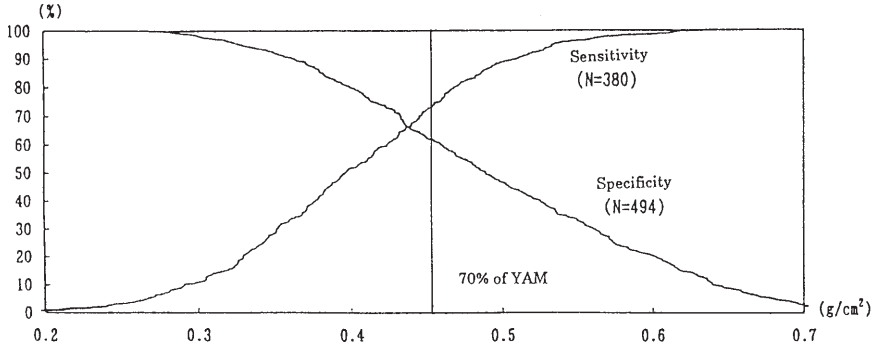

Fig. 9. Female: cutoff values of BMD of radius (DCS-600)

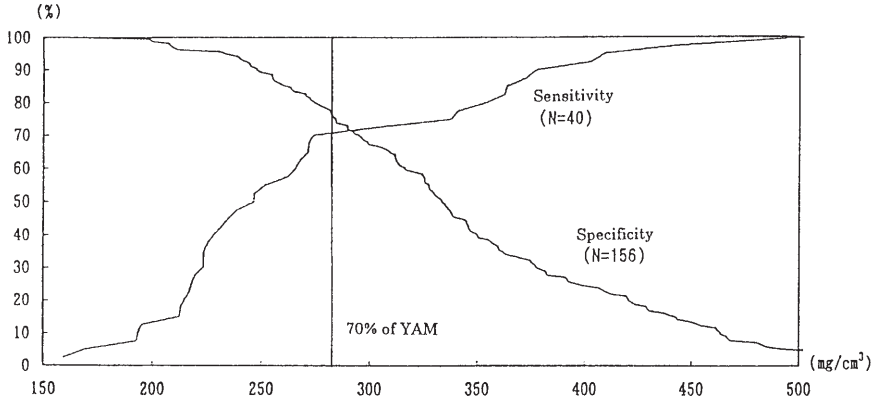

Fig. 10. Female: cutoff values of BMD of radius (XCT-960)

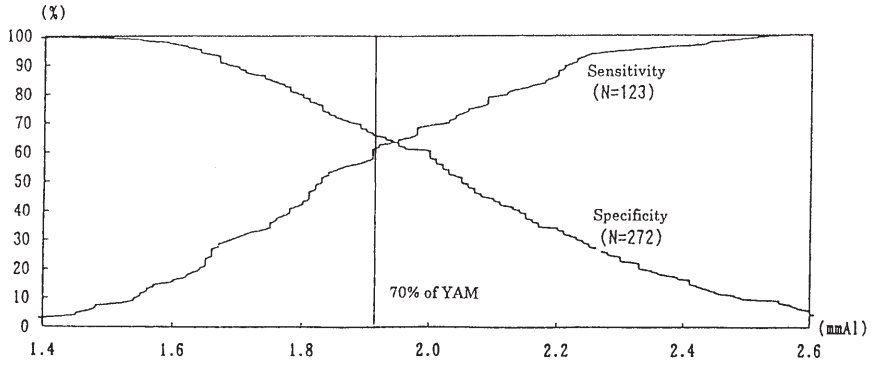

Fig. 11. Female: cutoff values of BMD of second metacarpal (CXD)

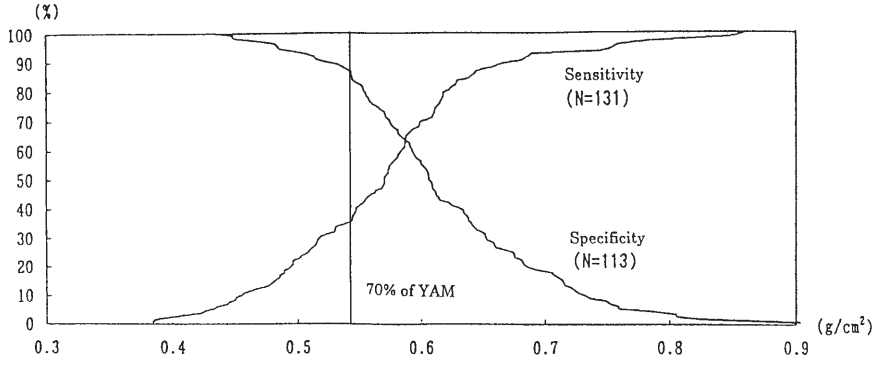

Fig. 12. Female: cutoff values of BMD of femoral neck (QDR)

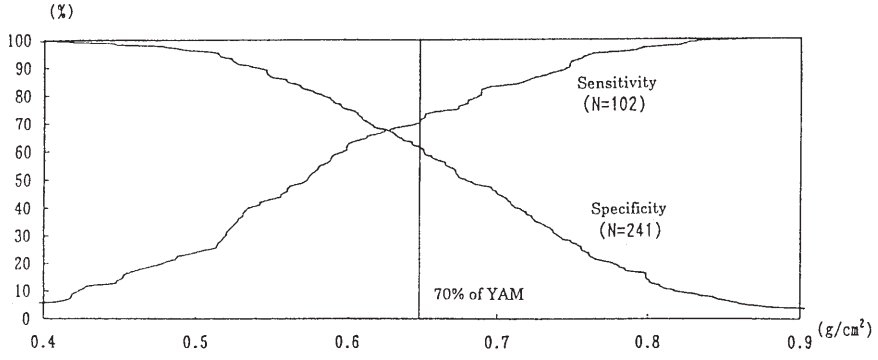

Fig. 13. Female: cutoff values of BMD of femoral neck (DPX)

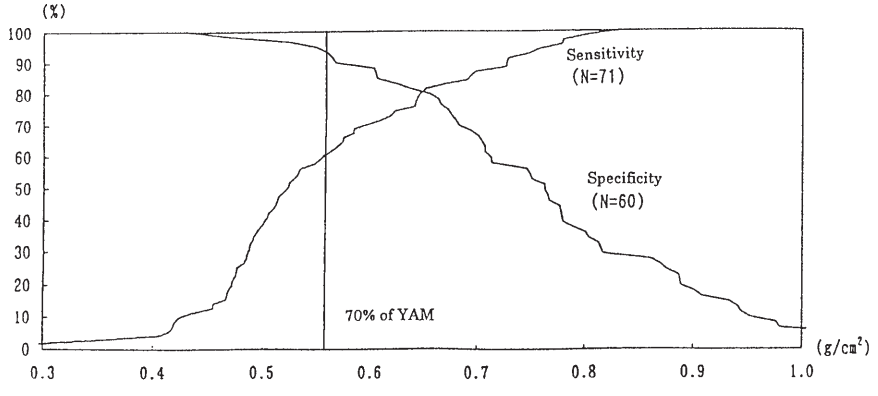

Fig. 14. Female: cutoff values of BMD of femoral neck (XR)

In this study, although there are some inconsistencies between different methods, sites, and types of machine, 70% of YAM was generally considered as the reasonable cutoff value at every site and with each type of machine. At the femoral neck (QDR, XR), the value corresponding to 70% of YAM was slightly lower than the BMD where the sensitivity curve intersects the specificity curve, possibly because of the younger age of the subjects and the potentially lower setting of YAM.

Another point to be considered is whether the cutoff values obtained here can be applied to measurements by other types of machine. When BMD was measured at the same site by the identical method with a different type of machine, there was a good correlation between values obtained with each type of machine. Therefore, it is considered to be reasonable to set it at 70% of YAM, because, as shown in Table 17, the change with age is similar to that at other sites. In conclusion, it is considered reasonable to set the cutoff values for BMD of lumbar spine, radius, second metacarpal bone, femoral neck, and calcaneus measured by each type of machine at 70% of YAM. The actual cutoff values for BMD are shown in Tables 18–22.

Although the primary objective of the present study was to determine the cutoff values for BMD, a difference was observed in the age of subjects between those with and without fractures. Because it is generally considered that the risk of fracture increases with age, further research and discussion may be required regarding whether the cutoff value should be changed with age.

Table 18. Female: cutoff values of BMD of lumbar spine

Machine	Total number of subjects	Number of YAM	YAM ± SD	80% of YAM	70% of YAM
QDR	12419	1089	1.011 ± 0.119	0.809 (=−1.7SD)	0.708 (=−2.6SD)
DPX	6344	816	1.192 ± 0.146	0.954 (=−1.6SD)	0.834 (=−2.4SD)
XR	5915	1313	1.040 ± 0.136	0.832 (=−1.5SD)	0.728 (=−2.3SD)
1X	6280	1802	1.084 ± 0.129	0.867 (=−1.7SD)	0.758 (=−2.5SD)

Table 19. Female: cutoff values of BMD of radius

Machine	Total number of subjects	Number of YAM	YAM ± SD	80% of YAM	70% of YAM
DCS-600	11035	1033	0.646 ± 0.052	0.517 (=−2.5SD)	0.452 (=−3.7SD)
XCT-960	5275	1298	405.36 ± 61.68	324.29 (=−1.3SD)	283.75 (=−2.0SD)
pDXA	6313	1078	0.753 ± 0.066	0.602 (=−2.3SD)	0.527 (=−3.4SD)
DTX-200	7254	2839	0.476 ± 0.054	0.381 (=−1.8SD)	0.333 (=−2.6SD)

Table 20. Female: cutoff values of BMD of second metacarpal

Machine	Total number of subjects	Number of YAM	YAM ± SD	80% of YAM	70% of YAM
CXD	15512	2140	2.741 ± 0.232	2.193 (=−2.4SD)	1.919 (=−3.5SD)
DIP	68224	25392	2.864 ± 0.247	2.291 (=−2.3SD)	0.834 (=−3.5SD)

Table 21. Female: cutoff values of BMD of femoral neck

Machine	Total number of subjects	Number of YAM	YAM ± SD	80% of YAM	70% of YAM
QDR	5627	381	0.763 ± 0.109	0.611 (=−1.4SD)	0.534 (=−2.1SD)
DPX	5062	592	0.914 ± 0.119	0.732 (=−1.5SD)	0.640 (=−2.3SD)
XR	9842	1308	0.803 ± 0.129	0.642 (=−1.2SD)	0.562 (=−1.9SD)

Table 22. Female: cutoff values of BMD of calcaneus

Machine	Total number of subjects	Number of YAM	YAM ± SD	80% of YAM	70% of YAM
Heelscan	5632	1935	0.842 ± 0.082	0.674 (=−2.0SD)	0.589 (=−3.1SD)

Correlation between BMD and radiographic osteopenia

BMD was measured and X-ray films of the lumbar spine (L2–L4) were taken in the same individuals within a 1-month period in 332 women. For this study, 145 women (mean age in years, 49.2 ± 6.8 SD) with grade 0 radiographic osteopenia (normal), 85 women (mean age, 58.8 ± 5.7 SD) with grade I radiographic osteopenia, and 102 women (mean age, 64.6 ± 8.0 SD) with grade II radiographic osteopenia were recruited. Then, analysis was done to consider the correlation between BMD and radiographic osteopenia of the lumbar spine. It was found that subjects with 1 degree of radiographic osteopenia have lumbar spine BMD approximately less than 80% of YAM, while subjects with 2 degrees of osteopenia have lumbar spine BMD approximately less than 70% of YAM (Figure 15). These data may justify our proposal of including radiograpic osteopenia of the lumbar spine as an index of diagnostic criteria.

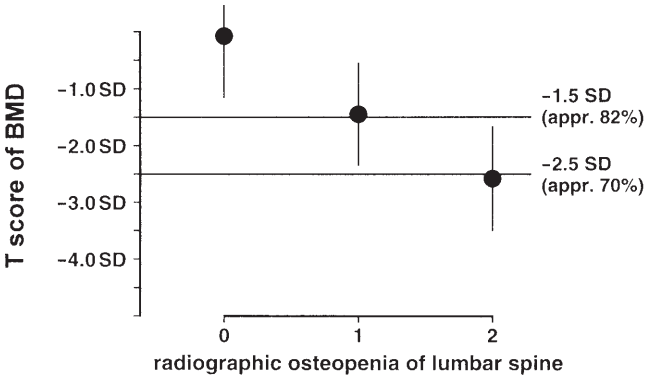

Fig. 15. Correlation between lumbar BMD and radiographic osteopenia of the lumbar spine. BMD was measured and X-ray films of the lumbar spine (L2–L4) were taken in 332 women: 145 (were grade 0), 85 grade I, and 102 grade II. *Crossed circles*, mean T-score of BMD in each subject of radiographic osteopenia; *vertical bars*, SD

How to use the diagnostic criteria of primary osteoporosis

To whom the diagnostic criteria should be applied

These diagnostic criteria should be applied to symptomatic patients with objective or subjective symptoms such as back/low back pain, thoracic kyphosis, etc., and those who have been advised to undergo a detailed examination after bone mass screening, etc. Such patients are first subjected to differential diagnosis according to the diagnostic manual of primary osteoporosis (see Fig. 5), followed by precise diagnosis using the new diagnostic criteria shown in Table 3.

Differential diagnosis

To make the diagnosis of primary osteoporosis, various diseases as listed in Figs. 1 and 2 and Table 1 must be ruled out.

Conclusion

Osteoporosis is a disease requring an interdisciplinary approach from different specialties including orthopedics, internal medicine (geriatrics), gynecology, and radiology. The present diagnostic criteria may be epoch making, as they were proposed as the consensus of scientists and physicians from various disciplines. These criteria present cutoff values of BMD in females for the lumbar spine (DXA), second metacarpal bone (CXD or DIP), radius (DXA, pQCT), femoral neck (DXA), and calcaneus (DXA) for which sufficient data are available from more than 5000 cases.

No sufficient data were available for males, and the diagnostic criteria for men should be proposed in the future. Therefore, it should be noted that the present criteria are based only on the current, temporal consensus. We expect that all those concerned with osteoporosis will understand this situation and use these diagnostic criteria in clinical practice.

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