CHAPTER VII GENERALIZATION

Exercise has been proposed as one strategy for improving or maintaining the structural competence of bone. Compared with the previous densitometric analysis using DXA which reported that aBMD increased with exercise, the studies using pQCT revealed that an improvement of the mechanical properties of adult bone in response to exercise is related negative changes in vBMD. Therefore, if exercise dose not increase vBMD, what dose it change? The pQCT study pointed out that periosteal area and endocortical area were significantly greater in the trained bone, together with the increase in bone strength (51). Furthermore, by assessing the geometric bone adaptation to mechanical loading, cortical thickness and mechanical properties (moment of inertia of area and SSI) of trained and sedentary bone were compared along 64 directions centering center of gravity of the bone on cross-sectional pQCT images (94). The differences in these parameters of the both groups depended on the direction of measurement suggesting that site-specific adaptation of bone to exercise is related to geographical relation of bone to muscle. Thus the improvement of the mechanical properties of bone in response to long-term physical exercise is related to geometric adaptation and not to vBMD (Figure 14).

Imaging technology such as pQCT (1,33,38,51) and MRI (3,17) consistently found a significant cortical drift in bones subjected to mechanical stress by exercise. However, there is one contradictory result. The side-to-side differences were analyzed on the radii of middle-aged female tennis players, who initiated training after bone had matured (61). It was found that compared with the non-dominant arms, the periosteal and endocortical areas of the dominant arms were smaller, in other words, the cortical drift toward the periosteal direction did not occur in dominant arms on middle-aged recreational tennis players. The different result may reflect that unilateral mechanical loading stimulated cortical drift only during the adolescent period but not after the third decade of life, and it also reflect the different intensity of exercise between young athletic and recreational players.

Since the present studies were conducted based on observations using pQCT, it is worth mentioning the limitations of the method. To limit X-ray radiation, pQCT scan has not been applied on whole bone but on a few selected slices in previous studies. The results therefore reflect a part and not a whole bone. Therefore, in the future study, it is expected that some other technical methods excelled in evolution, such as MRI (50,97,98), will be applied to investigating the effect of physical exercise on bone geometric architecture and bone strength of whole bone. On the other hand, the previous pQCT studies have mainly focused on cortical bone at bone shaft, since the resolution of pQCT still remains too poor in analyzing trabecular bone structure. At the distal epiphysis of long bone, the bone's mineral and structural response to exercise may differ from that described for the bone shaft because of greater proportion of trabecular bone. Recent studies have indicated that BMD of trabecular bone was more sensitive to the effects of exercise than that of cortical bone (91), and the trabecular architecture is also an important factor in assessing bone strength together with BMD (50). Thus it remains to be studied how the trabecular BMD, bone geometric architecture and bone strength adapt to the long-term physical exercise at the distal epiphysis.

Therefore, the present doctoral thesis comes to the conclusions that the improvement of the mechanical properties of cortical bone in response to long-term physical exercise, especially response to the weight-bearing exercise, is related to bone geometric expansion and not to increased vBMD. And the response seems to be related to geographical relation of bone to muscle. The effect of physical exercise depends on the age of subjects and the exercise elicits less geographical adaptation on matured bone, which has attained their peak bone mass.

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