Acute Changes in Biochemical Markers of Bone Resorption and Formation after Thai Traditional Massage

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Background: *Mechanical loadings by active exercise or passive low amplitude vibration have been demonstrated to enhance bone mass or delay bone loss. Traditional Thai massage can be anabolic to bone due to the application of physical loading on the body in a rhythmic fashion.*

Objective: *To explore the skeletal effect of Thai traditional massage by examining the changes in biochemical markers of bone turnover immediately after the massage.*

Material and Method: *Subjects consisted of 30 healthy females aged 20-40 years. Each subject received Thai traditional massage for 2 hours by a single masseuse. Bone mineral density (BMD) at baseline was measured by dual-energy X-ray absorptiometry (DEXA). C-terminal telopeptide of type I collagen (CTx-I) and total procollagen type 1 amino-terminal propeptide (P1NP) were determined by electrochemiluminescence immunoassay.*

Results: *There was a 4.8% increase in serum P1NP concentrations after massage (median 43.4 ng/ml vs. 41.3 ng/ml, $p < 0.05$). Serum CTx-I also decreased after massage (median 2-hour vs. baseline 0.29 ng/ml vs. 0.31 ng/ml, $p < 0.05$). There was a nearly significant negative correlation between the percentage change in serum P1NP and BMD at the total femur ($r = -0.37$, $p = 0.056$) whereas the statistically significant correlation disappeared between percentage change in bone turnover and the other sites of BMD.*

Conclusion: *Thai traditional massage induces acute changes in bone formation and resorption markers. Study on the more prolonged effects of Thai traditional massage is warranted to explore its implication in the enhancement of bone health.*

Keywords: *Thai traditional massage, Bone formation, Bone resorption*

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Osteoporosis is characterized by reduced bone mass and impaired bone quality. Bone mass is a result of the net effect of bone formation versus bone resorption which are under the influences of a number of factors. Unlike most other tissues, bone is sensitive to physical load. Physical loads from either active exercise or passive low amplitude vibration have been demonstrated to enhance bone mass or delay bone loss[1,2]. This effect is likely to be mediated by the strain-induced movement of extracellular fluid in bone lacunae where osteocytes reside which then influences osteoblasts as well as osteoclasts through signaling pathways delayed through cellular processes of osteocytes in the skeletal canaliculi[3,4].

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Traditional Thai massage exerts pressure on the body in a rhythmic fashion. The massage performer presses on the body of the subject through both outstretched heels of hands approximately once every 1-2 seconds for 2 hours. The pressure on the body exerted by the massage operator is heavy enough for some subjects to feel pain. It is, therefore, likely that the physical load from Thai traditional massage may induce strain in the skeleton and affect osteocytes like other means of providing mechanical load. Moreover, it has recently been demonstrated that a rest period between mechanical loads, which is also a characteristic of traditional Thai massage, is crucial for the anabolic effect of physical loads on bone[5]. Taken together, it is likely that Thai traditional massage can influence bone in a positive way. Currently there has been no clinical study investigating the effect of massage on the skeleton. It is, therefore, the purpose of the present study to explore the skeletal effect of Thai traditional

massage by examining the changes in biochemical markers of bone turnover immediately after the massage.

Material and Method

Subjects consisted of healthy females aged 20-40 years who had experienced Thai traditional massage before. Subjects having disorders that could affect bone metabolism such as hyperparathyroidism, thyrotoxicosis, diabetes and rheumatoid arthritis as well as those who were taking glucocorticoid or medications for osteoporosis were excluded. The present study was approved by the Institutional Review Board of Ramathibodi Hospital. All subjects gave signed informed consent prior to the present study.

Subjects were requested to refrain from exercise for 24 hours and fast for at least 6 hours before undergoing massage. Each subject received Thai traditional massage for 2 hours by a single masseuse. Subjects were requested to change into comfortable and loose clothes and lie flat on a firm mattress on the floor. The procedure consisted of the masseuse applying firm rhythmic pressure over the volunteer's body through the heels of her hands. The procedure started with both feet of the volunteer and then up to both legs, arms, hands, back, neck and ended with a head massage.

Bone mineral density (BMD) was measured by dual-energy X-ray absorptiometry (DEXA) (Lunar Prodigy; Lunar, USA). Daily calibration and quality control were done regularly according to the manufacturer's recommendation. BMD of lumbar spine 2-4, femoral neck and total hip were measured in each subject.

Blood samples were collected before and immediately after the massage. Biochemical markers of bone resorption; C-terminal telopeptide of type I collagen (CTx-I) and of bone formation; total pro-collagen type 1 amino-terminal propeptide (P1NP) were determined by electrochemiluminescence immuno-assay on a Cobas e 411 analyzer (Roche Diagnostic GmbH, Mannheim, Germany). The assays have intra-assay precision of 4.6% and 5.4% respectively.

Changes in biochemical markers of bone turnover after massage were assessed by Wilcoxon singed-rank test. Correlations among variables were examined by Pearson's correlation. A p-value of less than 0.05 was considered statistical significance.

Results

Table 1 shows the clinical characteristics of the study population. The mean age of the subjects was 31.5 $\pm$ 4.5 years. All had BMD within the normal premenopausal range and none had osteopenia or osteoporosis. Serum CTx-I decreased at the end of the 2-hour Thai traditional massage (median 2-hour vs. baseline 0.29 ng/ml vs. 0.31 ng/ml, $p < 0.05$). Individual value is shown in Fig. 1. Likewise, but in the opposite direction, there was a 4.8% increase in serum P1NP concentrations after massage as (median 43.4 ng/ml vs. 41.3 ng/ml, $p < 0.05$) as demonstrated in Fig. 2. Although post massage CTx-I and P1NP were correlated ($r = 0.673$, $p < 0.01$), there was no correlation between post massage and basal ratios of CTx-I and P1NP.

Table 2 demonstrates the correlations of the changes in biochemical markers of bone turnover to BMD at various skeletal sites. There was an almost significant negative correlation between the percentage change in serum P1NP and BMD at the total femur while the correlation with femoral neck BMD was not statistically significant. The correlation between percentage change in serum P1NP and total femoral BMD still approached statistical significance after controlling for age and BMI ($r = -0.36$, $p = 0.06$). In contrast to P1NP, no correlation between percentage change in CTx-I and BMD was found.

Discussion

The authors have demonstrated in the present study that external periodic mechanical loading applied through Thai traditional massage is likely to be anabolic to bone. To the authors' knowledge, this is the first report to demonstrate the anabolic effect on bone of mechanical loading applied through body massage. It is well established that mechanical load affects bone cells. The strain characteristics that determine skeletal responses include strain magnitude[6], strain frequency[7] and strain rate[8]. There appears to be an inverse relation between strain

Table 1. Clinical characteristics of the study population (n = 30)

Variables	Mean $\pm$ SD	Range
Age (year)	31.45 $\pm$ 4.5	23.4-39.7
Body weight (kg)	50.60 $\pm$ 4.4	41.8-57.5
Height (cm)	157.30 $\pm$ 4.1	146.5-164.0
Body mass index (kg/m^2)	20.40 $\pm$ 1.3	17.9-22.8
L2-4 BMD (g/cm^2)	1.18 $\pm$ 0.11	1.00-1.46
Femoral neck BMD (g/cm^2)	0.94 $\pm$ 0.11	0.73-1.24
Total femur BMD (g/cm^2)	0.97 $\pm$ 0.10	0.81-1.20

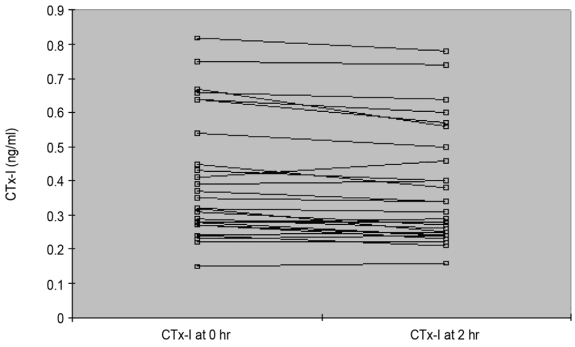

Fig. 1 Serum C-terminal telopeptide of type I collagen (CTx-I) at the beginning and at the end of massage

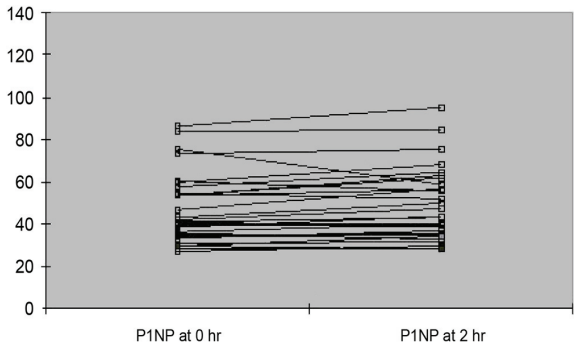

Fig. 2 Serum total procollagen type 1 amino-aterminal propeptide (P1NP) at the beginning and at the end of massage

Table 2. The correlation of the changes in biochemical markers of bone turnover to BMD at various skeletal sites

	Femoral neck BMD	Total femur BMD	L2-4 BMD	% change in P1NP	% change in CTx-I
Femoral neck BMD	1	0.917 $p < 0.010$	0.248 NS	-0.269 $p = 0.166$	-0.111 NS
Total femur BMD		1	0.340 $p = 0.077$	-0.365 $p = 0.056$	-0.037 NS
L2-4 BMD			1	-0.022 NS	-0.082 NS
% change in P1NP				1	0.048 NS
% change in CTx-I					1

NS = non significant

magnitude and frequency for inducing osteogenic effect. Low magnitude mechanical load needs to be applied at high frequency in order to possess equivalent effect to high magnitude mechanical load at lower frequency[9]. Although physical activity has been popularized as a means to improve bone health, the beneficial effect of physical activity on bone is not without dispute[10]. Moreover, adherence to exercise programs can be an issue[11,12]. Apart from the delivery of mechanical load through active exercise, a number of studies have investigated the utilization of low amplitude vibration applied at high frequency for enhancing bone mass in humans[2,13,14]. Such an approach is much less strenuous in nature and could be more successful in implementation particularly in the elderly population. The anabolic effect on bone of Thai traditional massage demonstrated in the present study suggests that Thai traditional massage could be another option for enhancing bone health through mechanical loading.

It is of note in the present study that the changes in biochemical markers of bone turnover can be discerned as early as at the time of completion of the 2-hour massage. Results from clinical trials of antiresorptive or bone formation agents usually show the changes in bone markers after months of therapy. Nevertheless, for the response to physical loading, the effects, which include increased bone formation, can be discerned within 5 days in experimental animals[15,16]. The acute changes in biochemical markers of bone turnover have also been demonstrated with the postprandial decrease in bone resorption in response to meals or oral glucose[17]. Moreover, acute change in bone markers has been demonstrated with oral calcium as well and the decrease in bone resorption marker can be apparent as early as 2 hours after the administration of calcium[18].

The authors have also demonstrated in the present study an almost negative correlation between the change in bone formation marker after massage

and total hip BMD. This approached negative correlation suggests against a higher BMD as a result of an intrinsic ability of the skeleton in some subjects to respond more to the accumulative influence of mechanical loading over time. On the contrary, this probably indicates the less responsiveness to mechanical loading in skeleton with higher BMD. In fact, in experimental animals, higher elastic modulus in bone having higher BMD has been demonstrated[19]. Less strain can thus be produced for a given stress resulting in less strain-induced osteogenic signaling in bone. It is also possible that there is no causal relation, one way or the other, between higher bone mass and less skeletal responsiveness to massage but the relation can be a result of certain common underlying factors. For example, estrogen has been shown to suppress the osteogenic effect of mechanical loading at the periosteal surface despite its well established positive effect on bone mass[20]. Genetic factors also play an important role in the determination of bone mass and responsiveness to mechanical loading. In humans, it has been demonstrated that there is an interaction between physical exercise, BMD and genetic variation in the catechol-O-methyltransferase (COMT) gene[21]. Likewise, genetic variation in the low-density lipoprotein receptor related protein 5 (LRP5) has also been shown to influence the relationship between physical activity and BMD[22].

In conclusion, Thai traditional massage induces acute changes in bone formation and resorption markers. A prolonged study is warranted to explore its implication of Thai traditional massage in the enhancement of bone health.

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ผลของการนวดแผนไทยต่อการเปลี่ยนแปลงค่าดัชนีการสร้าง และสลายมวลกระดูก

สุนีย์ แซ่ตั้ง, ละออ ชัยลือกิจ, บุญส่ง องค์พิพัฒนกุล

ภูมิหลัง: *มีการศึกษาพบว่าแรงกลที่เกิดจากการออกกำลังกาย หรือแรงสั่นสะเทือนที่กระทำต่อร่างกายนั้น ช่วยเพิ่มหรือชะลอการสลายมวลกระดูก สำหรับการนวดแผนไทยก็เป็นแรงชนิดหนึ่งที่กระทำต่อร่างกายซึ่งอาจมีผลต่อกระบวนการสร้างและสลายกระดูก*

วัตถุประสงค์: *เพื่อทดสอบผลของการนวดแผนไทยต่อมวลกระดูกโดยการสังเกตการเปลี่ยนแปลงของค่าดัชนีการสร้างและสลายมวลกระดูกก่อนและหลังได้รับการนวด*

วัสดุและวิธีการ: *อาสาสมัครเพศหญิงอายุระหว่าง 20-40 ปี จำนวน 30 ราย ทุกรายได้รับการเจาะเลือดเพื่อตรวจค่าดัชนีการสร้าง (total procollagen type 1 amino-terminal propeptide) และสลายมวลกระดูก (C-terminal telopeptide of type I collagen) ทั้งก่อนและหลังการนวดแผนไทย ระยะเวลาของการนวดทั้งสิ้น 2 ชั่วโมง โดยผู้นวดรายเดียวกันตลอดโครงการ และอาสาสมัครทุกรายได้รับการวัดความหนาแน่นมวลกระดูกโดยวิธี dual-energy X-ray absorptiometry*

ผลการศึกษา: *พบว่าดัชนีการสร้างมวลกระดูกเปลี่ยนแปลงเพิ่มขึ้น 4.8% โดยค่ามัธยฐานก่อนนวดเท่ากับ 41.3 ng/ml ค่ามัธยฐานหลังนวดเท่ากับ 43.4 ng/ml สำหรับค่าดัชนีการสลายมวลกระดูกลดลง โดยค่ามัธยฐานก่อนนวดเท่ากับ 0.31 ng/ml ค่ามัธยฐานหลังนวดเท่ากับ 0.29 ng/ml นอกจากนี้ยังพบว่า เกือบจะมีความสัมพันธ์แบบผกผันระหว่างค่าการเปลี่ยนแปลงของค่าดัชนีการสร้างมวลกระดูกกับมวลกระดูกบริเวณตะโพก ที่ค่านัยสำคัญทางสถิติเท่ากับ 0.056 (ค่าความสัมพันธ์เท่ากับ -0.37) แต่ไม่พบความสัมพันธ์นี้ระหว่างค่าการเปลี่ยนแปลงของดัชนีการสร้างและสลายมวลกระดูกกับมวลกระดูกบริเวณอื่น เช่น สันหลัง และคอตะโพก*

สรุป: *การนวดแผนไทยมีโอกาสก่อให้เกิดการปลี่ยนแปลงของค่าดัชนีการสร้าง และสลายมวลกระดูกดังนั้นควรทำการศึกษาต่อในระยะยาวถึงผลของการนวดนี้ต่อสภาวะสุขภาพกระดูก*