CHANGES OF THE PENETRATION STRENGTH OF THE LUMBAR VERTEBRAE TRABECULAR BONE OF ATHLETES DURING TRAINING

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KEY WORDS: athletic training with weight-lifting exercise, trabecular bone of lumbar vertebrae, penetration strength

INTRODUCTION: Athletes at the beginning of the sport season had training with weight-lifting exercises. Great static and dynamic loads during such athletic training influence the skeleton, especially the spine, of athletes. Some athletes feel pain in the lumbar region during training. Clinical studies have shown that lower back pain was caused by intensive loading of vertebrae (1).
The trabecular bone forms a large part of the vertebral body and intensive loads during training with weight-lifting exercise can cause changes of vertebral trabecular bone structural organization and strength without bone mineral content decreasing (11). Mentioned changes in the trabecular bone prohibit use of CT and DXA in early stages of the pathological process and create difficulties in selecting a level of loading intensity during training.
Osteopenetrometry was one of the methods which characterized trabecular bone strength and mechanical properties. Hvid et al. (9) described the osteopenetration method and equipment developed for measurements of trabecular bone strength during total knee replacement in vivo. The principle of this method is that a needle penetrates the trabecular bone tissue and during this penetration the pressure on the needle is registered. Experimental data suggested (9) that penetration strength was closely related to yield strength (r=0.87), the ultimate strength (r=0.86), Young's modulus (r=0.77), the yield energy absorption (r=0.81) and the ultimate energy absorption (r=0.84) derived from the compression tests.
The purpose of this study was to examine the changes of vertebra penetration strengths (PS) in the lumbar region of athletes during athletic training with weight-lifting exercise using this method.

MATERIAL AND METHODS: 120 athletes aged 18 to 26 (mean age - 23±2.8) from different sports (Tab. 1) were examined.

Tab. 1 The disciplines and sex of the examined athletes.

	Volleyball	**Basketball**	**Runners**	**Cycling**	
Female	16	10	14	8	48
Male	20	22	20	10	72

We examined the PS of 3 to 5 lumbar vertebrae on the 1st, 7th, 14th , 21st and 28th days of athletic training with weight-lifting exercise, according to the method described by Logins (12). In essence, the needle of osteopenetrometer is advanced at right angles to the surface of the proc.spinosus of the lumbar vertebra to be measured. During the penetration of the proc.spinosus a recording is

obtained of the force and depth of penetration. The needle used had a 90o conical measuring profile, with a base diameter of 1 mm. The depth of penetration was 3 mm. The average force per unit cross-sectional area of the measuring profile (in meg Pascal, MPa) is used to represent the penetration strength of the vertebra. The penetration strength was measured by the original apparatus, constructed and developed in the Laboratory of Biomechanics of the Medical Academy of Latvia.
Statistical analysis for the study was performed using the StatView statistics software (Abacus Concepts Inc., Berkeley, CA, 1992-93). Summary statistics were calculated as mean and standard deviation. Comparisons between athlete groups were made using a t-test. P-values less than 0.05 were considered statistically significant.

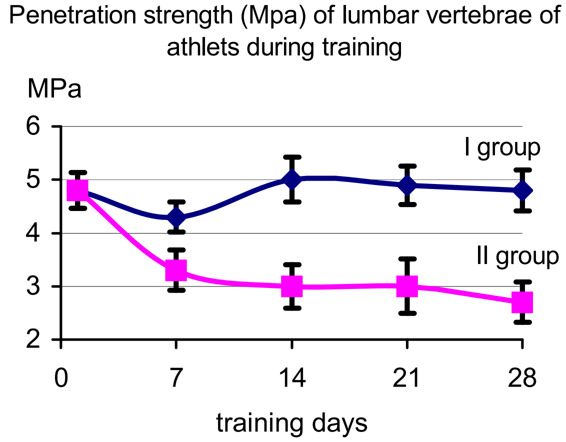
RESULTS: The PS of lumbar vertebrae of the athletes on the 1st training day was from 4.2 MPa up to 5.1 MPa. On the 7th day of training a decrease from 17% to 35% of the initial value of PS was noted. According to the level of PS decrease, we conditionally divided the athletes into two groups. The PS of the first group of athletes decreased by 20% of the initial value. The PS decrease of the second group of athletes exceeded 20% of the initial value (Tab. 2)

Tab. 2. The penetration strength (MPa) of the lumbar vertebrae of athletes during athletic training.

The group of athletes	**Examination stages**				
	1st day	**7th day**	**14th day**	**21st day**	**28th day**
I group(n=68)	4.8± 0.34	4.3± 0.28*	5.0± 0.42	4.9± 0.36	4.8± 0.38
II group(n=52)	4.8± 0.34	3.3± 0.38*	3.0± 0.41*	3.0± 0.51*	2.7± 0.38*

*- Statistically important difference

On the 14th day of athletic training the rehabilitation of the initial level of PS of the lumbar vertebrae was denoted for the first group of athletes and stayed the same during all the time of intensive load (28 days).



For the second group of athletes during the time of intensive load a decrease of PS of the lumbar vertebrae was noted up to 2.7±0.38 MPa on the 28th day of athletic training. On the 30th day after the end of athletic training with weight lifting exercises the PS were 4.9±0.31 MPa for the first group of athletes and 4.1±0.34 MPa for second group of athletes.

DISCUSSION AND CONCLUSION: The results of the present study indicate that endurance-training athletes (runners, sports games players, cycling) show similar and high lumbar spine trabecular bone PS compared with the normal population as reported recently (12).

Low bone mineral density at the lumbar spine has been reported (2,3,5,14) to occur in endurance-training athletes. The present study could not demonstrate such a difference in the strength of the lumbar spine in endurance-training athletes, which is in agreement with other studies (4,8,10).

In our study on the 7th day of intensive athletic training, decrease of lumbar spine PS to 35% of initial value was found. The results indicate that lumbar spine trabecular bone strength of endurance-training athletes can respond dramatically to loading characteristics (weight-lifting exercise) during training. Our findings are consistent with data showing that the level of physical loading with weight-lifting exercises had a negative correlation with the lumbar spine trabecular bone mineral density of endurance sports athletes (6,7,13,17). Taaffe DR. et al. (16) shown that the lumbar vertebrae trabecular bone mineral density of athletes decreased after intensive physical loading with weight-lifting exercises if preceding specific training did not take place.

Our results show different changes of PS in lumbar vertebrae of first and second groups of athletes during intensive training. The first group of athletes had a low correlation between PS values of lumbar vertebrae and duration of loading (r= 0.364). The second group of athletes had a negative correlation between PS values of lumbar vertebrae and duration of loading (r = -0.839). Low PS values of lumbar vertebrae of second group of athletes remained on the 30th day after the end of intensive training.

Analyzing the obtained data from the point of view of functional adaptation we can conclude the existence of at least three stages of adaptation. Short time – changes in lumbar trabecular bone mechanical properties appear just after application of loading. First stage of long term – appear after a certain time of prolonged new loading conditions, after restoration of previous loading conditions, the bone properties return to the previous state. Second stage long term adaptation – irreversible changes.

By taking into account the character of functional adaptation, PS values of the lumbar vertebrae of athletes and the duration of loading, it is possible to detect lumbar trabecular bone property changes due to intensive training and prevent the development of lower back pain.

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