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The effect of hand strengthening techniques in martial arts on bone mineral density – pilot study

Michal Vít, Boleslav Galkaniewicz, Martin Bugala

Faculty of Sports Studies, Masaryk University, Brno, Czech Republic

Abstract

Background and Study Aim. Hand strengthening techniques were used in most traditional Asian martial arts as preparatory exercise for hardening of striking areas, as injury prevention and a method for developing powerful striking techniques. They were also used for passing knowledge and tradition down to other practitioners. According to the Wolff's law, loading on a particular bone leads to remodelling of the bone overtime to become stronger and more resistant. The aim of the paper is the knowledge about the effect of 100-day lasting intervention programme of strengthening techniques on both hands of one tested person.

Material and Methods. For examination of the tested person three non-invasive methods were employed. X-ray apparatus, ultrasonography and densitometry were used for the description of physiological changes. Examination by X-ray, ultrasound and densitometer were conducted in a pre-test, during which the condition of the upper limbs before the workout was assessed. After completion of the intervention programme a post-test was conducted in which the condition of the upper extremities after exercise was described, assessing the difference between measurements. Assessment was done by doctors working in the field of radiology.

Results. The research showed an increase in bone mineral density in both hands after the intervention (right upper limb with BMD increased by 2.1%, the left upper limb with BMD increased by 1.6%). A stronger effect in the right hand was traced.

Conclusion. The research could not be considered as final evidence but as a pilot study for further more in-depth investigation of health benefits of the strengthening techniques witch should be conducted with larger number of tested persons.

Key words: combative • healthy lifestyle • self-defence • security • sports

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Corresponding author: Michal Vít, Faculty of Sports Studies, Masaryk University, Kamenice 753/5, 625 00 Brno, Czech Republic; e-mail: vit@fsps.muni.cz

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Introduction

The theory of Asian martial arts describes special training methods aimed for strengthening of striking areas of human body and preparing the practitioner for combative performance. Roots of such strengthening techniques can be traced back to Shaolin temple were six hand techniques were used for strengthening fingers and other parts of a striking hand [1]. Kennedy & Guo [2] state that some of the best known special training methods are various forms of iron hand training. These training procedures were aimed for strengthening of hand striking areas to increase fighter's ability to strike with maximum impact without damaging their hand [2]. The purpose of this exercise was therefore not only to develop effective striking techniques, but also prophylaxis of hand injury, which, due to the further development of combat situations, could have fatal consequences. Current definition of combatives by Reguli [3] mentions that combative activities comprise also specific exercise which prepares a participant to overcome a partner by physical contact. Strengthening techniques are a good example of this definition.

In the past in Chinese martial arts not only methods of strengthening hands but also forearms, shins, the whole body, or even the head would occur. Kiew [4] reports that such specialized training should be performed daily, i.e. in the morning, afternoon or evening in the length of half an hour or longer. Martial artists perform striking rice, beans, peas, sawdust, sand, gravel, and in the last stages steel balls [5]. Some students show their level of strengthening their striking areas by breaking bricks, stones, or desks just using those strikes that were practiced in training. The shift from strengthening striking surfaces to breaking techniques is possible within a few months. Students are able to apply the proper striking mechanics and lead the strike in a faster and harder way. Shaolin monastery is also mentioned as a source of qinna techniques. Chinese word „qin" means „to grasp" and the word „na" means „to control". Qinna is the art of controlling the opponent with grasping techniques, whose main purpose is to block breathing, arteries, and to strike and press on acupressure points [5]. Due to the need of leading strikes on very small vital points of the human body not only large striking areas of hands but also fingertips are being strengthened during qinna training. Qinna techniques are not a separate fighting style but to a lesser or greater extent, according Balner [5], the vast majority of Chinese styles are involved.

Also in Japanese martial arts strengthening techniques are very popular. Typical example of them is practice on the makiwara striking post. The makiwara is a Japanese word meaning forging post. In metaphorical meaning the use of makiwara is a process of forging fist like a blacksmith, which should lead to creating iron-like tool for raw punching power [6]. There is empirical evidence about the effect of strengthening techniques using makiwara or other tools in martial arts on the human body. Egami [7] describes that training on makiwara will lead to forming blisters on the areas of the hand that come into contact with it and calluses will form on the knuckles with further practice. Egami [7] also states that cartilage will have formed around the bone, which was confirmed by x-ray apparatus. Black [6] affirms that makiwara training may be of benefit to the karate practitioner, causing greater bone density in the areas of impact referring to the Wolff's law. The effect of mechanical stress on bones and their re-modelling is described in literature as follows. The direction and thickness of trabeculae in cancellous bone are related to regional stress trajectories. According to the Wolff´s law the architecture and mass of the skeleton are adjusted to withstand the prevailing forces imposed by functional need or deformity [8]. Bone constantly adapts to the stresses imposed upon it and at any particular site cortical and trabecular thickness will be greatest in the trajectories of highest stress [9]. Bone´s structural adaptation to mechanical usage was dealt by Frost [10] who also refers to the Wolff's law which says: „Every change in the form and function of bone or of their function alone is followed by certain definite changes in their internal architecture, and equally definite alteration in their external conformation, in accordance with mathematical laws" [11]. We can conclude that according to the Wolff's law loading on a particular bone will lead to remodelling of the bone overtime to become stronger and more resistant.

Influence of martial arts training on the musculoskeletal system was dealt by many authors from different aspects [12–17]. Eckert & Lee [13] identified anatomical principle of nikkyo techniques in aikido which leads to acute pain and long-term pathological changes. Shin et al. [14] suggested that taekwondo training during growth significantly improved bone health of young female athletes in all weight groups. The influence of karate training on the health of hands was dealt in the study by Crosby [12]. In his study 22 hands and wrists of 22 karate instructors who had practiced karate for a minimum of five years were reviewed. Seventeen tested person regularly trained on the makiwara and all 22 performed between fifty and

one hundred push-ups on the knuckles every day. Radiological evidence of a total of ten fractures was found. Apart from revealing evidence of previous fractures, X-ray film of the hands showed none of the features of osteoarthritis at the metacarpophalangeal joints or carpometacarpal joints, and the radiological density of the metacarpals was normal. Crosby [12] concludes that long term and routine practice of karate does not appear to predispose to the early onset of osteoarthritis or tendonitis in the hands and wrists. Hsu et al. [16]Tai chi group and control group. The exercise program consisted of 60 min of exercise three times per week for 12 weeks. The circuit exercises were carried out with intensity controlled by heart rate (60-80% of work investigated the impact of circuit exercise and Tai chi exercise on body composition in middle-aged and older women. As the same author [15] reported earlier there is positive correlation between basal metabolic rate (BMR) and bone mineral density (BMD). Lip et al. [17] examined the effect of Ving Tsun (VT) Chinese martial art training on radial bone strength in elderly participants. VT involves repetitive upper limb striking movements that continually load high peak forces and impacts on the forearm bones. Lip et al. [17] state that the bone strength of the distal radius, therefore, increases to accommodate these mechanical demands. In present research the radial bone strength of the VT group improved by 28.9 % over time, whereas the no-training control group improved by only 11.3%. This improvement can be explained by the constant upper limb striking movements three months of VT intervention. Lip et al. [17] also refer to the Wolff´s law and conclude that the repetitive forces and impacts on the forearm bones during sticking-hand drills should enhance distal radial bone strength to accommodate the increased mechanical demands.

There are some assumptions and evidence about the effect of martial arts training, especially strengthening techniques on the human body, which should lead to re-modelling of bones and hardening the striking areas [5–7,14,17]. That is why we decided to examine the assumption about prophylactic purpose and health benefit of these exercises. The article focuses on testing the hypothesis that practice of strengthening techniques in martial arts leads to increase of bone mineral density.

Material and Methods

Tested person

For selection of a test person the following criteria were set: a man or woman with at least 5-year-experience in the martial art that uses the technique of striking without medical contraindications for strengthening techniques, e.g. previous hand injuries. On the basis of these criteria was for the purpose of the pilot study chosen a man of white ethnicity aged 24.3 years, height of 175 cm, weight of 84.5 kg having 10-year-experience in martial arts and combative sports (kyoukushinkai karate, kick boxing, K1, aikijujutsu, aikido, taekwondo, wing tsun) in good health condition without previous injuries of his hands. Tested person was informed about procedures during the experiment. All examination methods of the tested person used in experiment are non-invasive. Strengthening techniques programme is commonly used in martial arts. That is why no objective risk was present in experiment and all procedures were in accordance with the ethical standards of the responsible institutional committee.

Selection of strengthening techniques programme (STP)

Intervention programme (STP) was selected on the basis of literature research so that it was especially gentle to the body, possible to be involved in a daily program of the tested person and with proclaimed effect that should occur within months. For the selection method the following criteria were set:

1. STP should be implemented using the indirect method (using fabric between hands and striking materials);

2. STP should be performed twice a day;

3. STP should begin with a warm-up;

4. STP should be based on the hypothesis of bone remodelling after intervention within hundred days;

5. STP should be accompanied by treatment of striking areas by traditional herbal preparations.

For research purposes, the iron palm method by Balner was chosen [5]. This method meets all the criteria and is described in detail in the literature. According to this method the hand bone remodelling occurs after exercising twice a day for a hundred days.

Description of strengthening techniques programme (STP)

The intervention programme included training according to the method of iron hand which is

described in detail by Balner [5]. The method is based on strikes led on a bag 40 cm long, 25 cm wide and 8-14 cm thick, which is in the beginning filled with rice, later with beans or peas, and in the subsequent stages of training with gravel or steel balls. In the case of our research the time was divided as follows: 33 days of strikes to the apparatus filled with rice, further 33 days of strikes to the apparatus filled with gravel with a weight of shot size (4.46 mm), and finally 34 days of strikes to the apparatus filled with pellets. When selecting methods and materials, the emphasis was put on safety, loading sequence and a target of interventions, while persevering in the STP for one hundred days. Therefore, in the initial phase of the programme rice was selected as, in terms of subjective feelings of pain, it is the simplest material. Gravel is comparable to coarse sand, and for that reason the shift from the preceding material should be continuous. Shots were chosen as the last and hardest material. Sequential loading of the organism from the finest to the hardest material is also advantageous because in case of complications during the experiment, it is possible to go back to the previous striking material, which in the case of one striking material or technique performed on makiwara would be impossible.

Each session started with warming up shoulders, elbows, wrists and fingers. Strikes were performed by the palm, the back of the palm, fingertips, knife-hand and fist. Each time two series of thirty repetitions of each hand by all striking surfaces were performed. Before and after each exercise herbal preparation called Dit Da Jow was applied and hands were massaged.

Methods

For examination of the tested person three non-invasive methods were employed. X-ray apparatus, ultrasonography and densitometry were used for the description of physiological changes. Examination by X-ray, ultrasound and densitometer were conducted in a pre-test, during which the condition of the upper limbs before the workout was assessed. After completion of the intervention programme a post-test was conducted in which the condition of the upper extremities after exercise was described, assessing the difference between measurements. Assessment was done by doctors working in the field of radiology.

Ultrasound examination is used for examination of soft tissues, and it could detect damage to muscles, tendons, and tendon sheaths or tendonitis. For examination of the tested person GE Logiq 400 ultrasound system were employed.

The radiograph shows the position of the bones and joints. This investigative method can detect eventual deformity, micro trauma or post-traumatic changes. It may also be used to detect point indicative of bone density in the skeleton of both hands. But X-ray signs of bone loss are late and unreliable. Densitometry is much more accurate way of measuring bone mineral density (BMD) and bone mass [9]. That is why we used DXA GE Prodigi densitometer. Bone densitometry measures in grams per square centimetre the amounts of bone minerals in the monitored section of the bone. Test results of the densitometer examination are expressed as a T-score or Z-score. T-score reflects the number of deviations of the result of the examination from the table values of bone mineral density of young and healthy individuals of the same gender. Z-score expresses the same figure, but compares the test results with average values in people of the same gender and age. The score SD +2.5 to –1 SD is considered normal. Densitometry is considered to be an optimal diagnostic method for detecting the effect of an intervention programme on bone mineral density. To increase the security and control of the experiment complementary methods of data collection such as photographs and a diary of the tested person were used. The diary recorded the dates and times in which the exercise was carried out, the materials used for STP and subjective exercise soreness. Although the pain is subjective, individual perception, which cannot be objectively measured, verbal scale of pain is used in examination. In our research a five-point scale was employed, the purpose of which was to monitor the progress of STP and feedback of the tested person. Description of the scale is as follows: 0 = no pain, 1 = little pain, 2 = moderate pain, 3 = severe pain, 4 = excruciating pain. There is also a note in the diary with description of further exercise that was carried out on that day or problems and events related to the strengthening training.

Results

Pre-test

During the X-ray examination no abnormalities, micro trauma or other contraindications that would make it impossible to launch STP were found. Sonography examination showed no damage to muscles, tendons, tendon sheaths or tendinitis.

The densitometry examination conducted on 21st August 2014 revealed BMD of 1.031 g/cm^2 of the right upper limb using 33% radius examination. The T-score was determined by + 0.4 SD. The densitometry examination revealed BMD of 1.127 g/cm^2 of the left upper limb using 33% radius examination. The T-score was determined by +1.4 SD. Result of the densitometry: the values are within normal limits.

Post-test

A control X-ray examination revealed that there is no increased occurrence of any symptoms of osteoarthritis, deformity or post-traumatic changes on the skeleton of hands including small interphalangeal joints. On the contrary, adequate increase in point bone density on the skeleton of both hands including the carpals was identified, which corresponds to densitometry of both forearms. The sonography examination showed no apparent changes in the area of tendons, fingers and forearms.

Densitometry examination showed that after 100 days of continuous intervention there was an increase of BMD. On the right upper limb BMD of 1.053 g/cm^2 was measured in 33% of radius. The T-score was determined by + 0.6 SD. On the left upper limb BMD of 1.145 g/cm^2 was measured in 33% of radius. The T-score was determined by + 1.6 SD. The result of the densitometry: the values are within normal limits.

Based on the set design of the research the hypothesis was confirmed. In comparison to the results of the pre-test and post-test it was revealed that BMD in the right upper limb increased by 2.1%, and BMD on the left upper limb increased by 1.6%.

Discussion

Measurements conducted on one person before and after a 100-day intervention brought interesting findings pointing to an increase in BMD on both arms of the test person (right upper limb with BMD increased by 2.1%, the left upper limb with BMD increased by 1.6%). During the exercise, only minor changes to striking areas such as blistering and peeling of hard skin appeared. The pain was assessed according to the degree of 0 (no pain) of a selected range. The exception was the period of four days, when a blister on the left hand appeared and that gradually ruptured. During these four days, the pain was assessed at level 1 (small pain).

Before we set a conclusion, we have to consider some limitations of the research. In particular, this is a pilot study conducted on one subject aimed to select and validate the feasibility of implementing a particular method of strengthening exercise. The research results cannot be generalized or compared with other research of the same design that uses the same pre-test, intervention lasting 100 days and a post-test, because during the search no study on BMD measurements on tested persons of comparable age was found. Moreover, it is also necessary to take into account the deviation of measurement of whole body DXA densitometer. Mazess et. al. [18] state that the deviation of the GE device of Prodigy series on which measurements were performed should be in partial and whole body BMD measurement on the level of 0.5% in vitro and 1% in vivo. With respect to the deviation of the measurement it is possible to infer a significant difference especially on the right upper extremity. The left upper limb is less significant considering the deviation. More significant difference in BMD values of the right upper extremity shows the fact that the tested person is right-handed and strikes during STP were performed stronger by right than left hand. Higher loads should therefore, according to Wolff's law, lead to greater adaptation and remodelling of bone. Another variable that could affect the measurement results is exercise performed parallel during the experiment (martial arts and self-defence training, kettlebell, powerlifting and crossfit training). However, this exercise is not of great significance, as it had been done a long time before the experiment. Thus affecting the results during the ongoing 100 days intervention is not probable. Also, it is important to mention, that 98% of the body´s calcium and 85% of its phosphorus is tightly packed in bone and can be released only by resorption of the entire tissue. Calcium absorption is mediated by vitamin D metabolites and inhibited by excessive intake of phosphates (common in soft drinks), oxalates (found in tea and coffee) and fats. Vitamin D, through its active metabolites, is principally concerned with calcium absorption and transport and (acting with parathyroid hormone) bone remodelling [9]. Vitamin D intake could be influenced by sunlight exposure or diet. We have to consider that eating habits of tested person were not taken into account during the research. The last factor to be discussed is the use of Dit Da Jow herbal medicine. Chemical analysis of the product and its possible influence on BMD was not a part of the research.

Except for objective data obtained from the measurement we consider also subjective feelings of

the tested person to be valuable. According to him thanks to STP there was significant strengthening of his wrists and improvement of strike techniques. Strikes carried out in combat activities have thus become stronger mainly because of right strengthening of the hand just before they strike the target. Physical performance is also affected by mental condition. Improvement of strike technique was caused by a decreased fear of possible injury. Thus STP also contributed to positive changes in cognitive areas, i.e. understanding of leading the strike without protective means.

Conclusions

The research showed an increase in bone mineral density in both hands after intervention. In the selected person appeared after the intervention programme of strengthening exercise increase of BMD in both hands (right upper limb with BMD increased by 2.1%, the left upper limb with BMD increased by 1.6%). Bigger difference in BMD values of the right upper extremity shows the fact that the tested person is right-handed and right-hand strikes performed during strengthening techniques programme were stronger than left-hand ones. This corresponds to Wolff's law according to which the higher load should lead to greater adaptation and bone remodelling. Although the results of measurements showed an increase of BMD in both hands, with regard to the above discussed factors such as deviation of DXA densitometer, diet etc., conclusions are not unambiguous. The research could not be considered as final evidence but as a pilot study for further more in-depth investigation of health benefits of the strengthening techniques witch should be conducted with larger number of tested persons.

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This pilot study was designed to evaluate the effects of 12 weeks of MAE intervention on body composition, serum bone biomarkers and QOL in overweight/obese premenopausal women. In addition, obesity-related parameters including lipid profiles, insulin-like growth factor-I (IGF-I), leptin, and CRP were also assessed.Â The current MAE covers these common techniques taught in major styles of martial arts such as Taekwondo, Karate, Kung Fu, boxing, Kickboxing, Muay Thai, Judo, Aikido, and Jujitsu. MAE class attendance for each participant was recorded to calculate the attendance rate as the number of sessions completed divided by the total number of sessions prescribed. This pilot study determined whether older individuals could learn martial arts (MA) fall techniques and whether this resulted in a reduced hip impact force during a sideways fall. Methods. Six male and nineteen female healthy older individuals completed a five-session MA fall training.Â Hochberg MC, Greenspan S, Wasnich RD et al (2002) Changes in bone density and turnover explain the reductions in incidence of nonvertebral fractures that occur during treatment with antiresorptive agents. J Clin Endocrinol Metab 87(4):1586â€“1592CrossRefPubMedGoogle Scholar. 6.