Telaah Pustaka

Physical Exercise and Bone Health

Gadis Meinar Sari
Physiology Department, Faculty of Medicine, Universitas Airlangga
Jl. Prof. Dr. Moestopo 47, Surabaya. Phone: +6231 5023621

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ABSTRACT

Exercise was a planned and structured physical activity in which there was a movement repetition to maintain or enhance one or more components of physical fitness. The physical exercise on biological functions gave positive effects such as improving, but in certain circumstances, it could also give a negative effect such as inhibiting or disturbing the level of individual, system, cell, and molecular. Likewise the effect of physical exercise on bones, many factors affected bone both positively and negatively, among others; the dose of physical exercise which included frequency, intensity, type and time. The dosage of physical exercise was individual on each person. Some studies found that moderate intensity physical exercise provided positive benefits on bones. One of them was affecting the process of proliferation and differentiation of osteoblast, which was one of bone cells that had a function to form bone matrix. Moderate intensity physical exercise combined with salmon calcitonin would increase mouse bone density. Moderate-speed walking exercise would cause changes in IL-6 serum levels which had a role in the process of stem cell differentiation into osteoprogenitor and directly affected adult osteoblasts, whereas changes in PTH serum levels in the sub-acute phase of exercise played a role in the positive uncoupling process of bone remodeling directly.

Keywords : moderate intensity physical exercise, bone health
Correspondence to : gadis-m-s@fk.unair.ac.id

ABSTRAK

Olahraga adalah latihan fisik yang merupakan bagian dari aktivitas fisik yang terencana, terstruktur, terdapat repetisi gerakan, dan mempunyai tujuan mempertahankan atau meningkatkan salah satu atau lebih komponen kebugaran fisik. Pengaruh latihan fisik terhadap fungsi biologis dapat memberi pengaruh positif yaitu bersifat memperbaiki, akan tetapi pada keadaan tertentu dapat pula memberikan pengaruh negatif yaitu menghambat atau mengganggu baik pada tingkat individu, sistem, sel maupun molekul. Demikian juga pengaruh latihan fisik terhadap tulang, banyak faktor yang mempengaruhi tulang secara positif maupun negatif, antara lain adalah dosis latihan fisik yang meliputi frekuensi, intensitas, jenis dan waktu melakukan latihan fisik. Dosis latihan fisik bersifat individual pada setiap orang. Beberapa penelitian menunjukkan bahwa latihan fisik intensitas sedang memberikan manfaat positif pada tulang. Antara lain mempengaruhi proses proliferasi dan diferensiasi sel osteoblas yaitu salah satu sel tulang yang berfungsi membentuk matriks tulang. Latihan fisik intensitas sedang dikombinasikan dengan salmon kalsitonin akan meningkatkan kepadatan tulang tikus. Latihan jalan dengan kecepatan sedang akan menyebabkan perubahan kadar IL-6 serum yang berperan pada proses diferensiasi *stem cell* menjadi osteoprogenitor dan secara langsung berpengaruh pada osteoblas dewasa, sedangkan perubahan kadar PTH serum pada fase subakut latihan berperan pada proses *positive uncoupling* remodeling tulang secara langsung.

Kata kunci : latihan fisik intensitas sedang, kesehatan tulang
Korespondensi : gadis-m-s@fk.unair.ac.id

INTRODUCTION

The increasing life demand nowadays causes an increase of workload; therefore people are required to pay attention to their health in order to stay healthy and fit in the midst of their busy life. Many efforts have been done to maintain health such as consuming healthy foods, maintaining a resting pattern, and also doing exercise regularly. Exercise is a planned and structured physical activity in which there is a movement repetition to maintain or enhance one or more components of physical fitness.

Physical exercise influences system functions of body including respiratory, cardiovascular, nervous and musculoskeletal systems. The physical exercise on biological functions gives a positive effect such as improving, but in certain circumstances, it can also give a negative effect such as inhibiting or disturbing the level of individual, system, cell, and molecular.

Likewise the effect of physical exercise on bone, recent research has revealed effects of physical exercise on bone health at the individual, system, cell and molecular levels. Many factors affect bone both positively and negatively, among others; the dose of physical exercise which includes frequency, intensity, type and time. The dosage of physical exercise is individual that means each person has their own exercise dosage. If physical exercise is carried out using the right dosage, it will give a positive effect, but on the contrary physical exercise that is carried out with high or exceeding dosage, it will give a negative effect on organs or tissues functions, one of them is bone.

DISCUSSION

Physical Exerise and Bone Metabolism

Exercise is a planned and structured physical activity in which there is a movement repetition to maintain or enhance one or more components of physical fitness. As well as drug administration, physical exercise also requires the right dosage for every human being in order to give a positive effect; that is to fix or to improve organs function. The dosage of physical exercise includes mild, moderate and high doses. Calculation of physical exercise dosage is based on frequency, intensity, time and type of exercise. Physical exercise affects the function of human body system such as respiratory, cardiovascular, nervous and musculoskeletal systems. Proper physical exercise will give a positive effect on bone metabolism.

Bone metabolism is a change of bone structure that occurs continuously throughout life including the process of resorption by osteoclasts and formation by bone osteoblasts. Physical exercise encourages changes of bone metabolism through direct and indirect effects. Direct effects are through mechanical force while indirect effects are through micro-environment including hormonal factors, cytokines, and vitamins. Mechanical force applied to bone tissue forms endogenous signals captured by the mechanosensory system that will be captured by osteocytes and then transform into biochemical signals that regulate bone remodeling. Mechanical force stimulates prostaglandin E2 (PGE2) release from gap junction. PGE2 will bind receptors on osteocytes and stimulate protein formation that becomes bone matrix. Physical exercise causes changes in the process of bone remodeling, whose response depends on exercise dosage (Rantalainen, 2009). The body has the ability to respond and adapt to the addition of physical exercise dosage, including frequency, intensity, time and type.

Effects of Moderate Intensity Physical Exercise

Many studies found that moderate intensity physical exercise can increase bone density. Mahmudati (2008) showed that moderate intensity physical exercise can increase bone density through biological action of estrogen which involves estrogen receptor activity (ERα). Mechanical stimulation, in this case moderate intensity physical exercise, can activate ERK1/ 2 (Extracellular Signal Regulated Kinase). Activation of ERα and ERK1/ 2 will activate IGF-IR, thus affect the process of proliferation and differentiation of osteoblast cells, which is one of bone cells that have a function to form a bone matrix.

Other researchers have even described molecular level influences through stem cell development. Tinduh (2012) revealed that moderate-speed walking exercise is a form of osteogenic mechanical functional stimulation, which will cause changes in bone remodeling. Activation of bone remodeling after moderate speed walking exercise mobilizes stem cells, differentiation and maturation into osteoprogenitor cells in peripheral blood mononuclear cell (PBMC) which causes positive uncoupling of bone remodeling in postmenopausal women. The role of moderate speed walking exercise also affects the dynamics of IL-6 and PTH serum which have specific patterns related to time dimension. Changes of IL-6 serum levels in the sub-acute phase of exercise play a role in the process of stem cell differentiation into osteoprogenitor in PBMC and directly on adult osteoblasts, whereas changes of PTH serum levels in sub-acute phase of exercise play a role in positive uncoupling of bone remodeling directly.

Lesmana HS (2013) stated that submaximal physical exercise, a physical exercise with a moderate to high loading level, which is combined with salmon calcitonin increases bone density in growing white mice. Physical exercise stimulates growth hormone secretion (Growth Hormone; GH), one of hormones that plays a role in bone growth. Submaximal intensity physical exercise is a stressor that will stimulate the anterior pituitary to secrete GH. GH will stimulate liver to produce Insulin-like Growth Factor-1 (IGF-1) which will improve the performance of osteoblast cells, while performance of osteoclast cells will decrease, thus bone formation will be higher than the process of bone resorption. While the role of salmon calcitonin supports the process of bone-compaction. Calcitonin works on bones through two pathways, first, in the short term that is reducing calcium transfer from bone to plasma by inhibiting osteoclast motility. Second, it prevents the formation of new osteoclasts from osteoprogenitor cells.

Effects of High Intensity Physical Exercise

Several studies have proven that high-intensity physical exercise has negative impacts especially on bone thus bone density becomes lower. The administration of exercise dosage that exceeds threshold value of body's adaptability will be a stressor for the body. High-intensity physical exercise will increase cortisol secretion, which is the main glucocorticoid. High glucocorticoid level can interfere body function balance resulting in pathological consequences, one of which is bone.

A study by Sari GM (2012) on white rats given high intensity swimming exercise; 18% loading of body weight in 90% of its maximum time that is carried out twice per set with a frequency of 3 times per week for 8 weeks, showed that there was a disturbance of bone remodeling. It is due to an increase of glucocorticoid levels causing a decrease in osteoprotegerin levels, thereby increasing c-telopeptide levels. Osteoprotegerin is a soluble decoy receptor released from stromal or osteoblast cells that has a binding effect on

RANK, thus it can inhibit RANKL-RANK interactions to increase osteoclastogenesis. Glucocorticoids suppress OPG mRNA expression especially in human osteoblasts and osteoblast cell lines, inhibit OPG production, and increase production of RANKL osteoblasts. On the other hand, an increase of glucocorticoid levels will cause a decrease of osteocalcin levels that is not through the osteoblast apoptotic pathway. Increased c-telopeptide level and decreased osteocalcin level will increase the ratio of c-telopeptide/ osteocalcin so that there is an imbalance or disruption of bone remodeling in negative uncoupling. The pathway that has more role in the disruption of bone remodeling due to high intensity physical exercise is the pathway for decreasing osteoprotegerin levels which increasing c-telopeptide levels.

This study shows that exercise with improper dosage will give adverse effects on body such as disruption of organs or tissue. This is a warning for us or all sport lovers to do sports according to the ability of our body or individual dosage. A study by Sari GM (2010) on white mice showed that there was an increase in apoptosis of bone lining cells in group treated by high-dosage of glucocorticoid rather than moderate-dosage or untreated controlled group, as shown in Figure 1, 2, and 3. This basic study illustrates that excessive glucocorticoids in the body can also occur in sportsmen/ athlete with high intensity physical activity, can cause apoptosis of lining cells osteoblast; that is osteoblast reserve cells originating from mesenchymal stem cells.

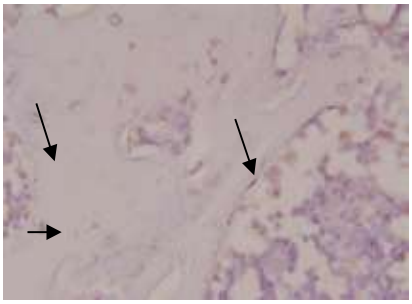

Figure 1: Bone lining cells in controlled group (Sari GM, 2010)

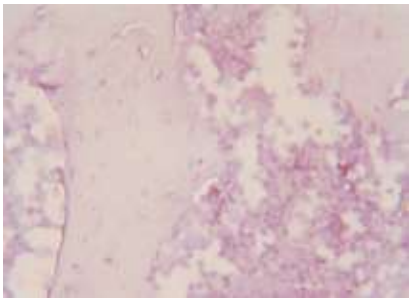

Figure 2: Apoptotic bone lining cells in moderate-dosage of glucocorticoids group (Sari GM, 2010)

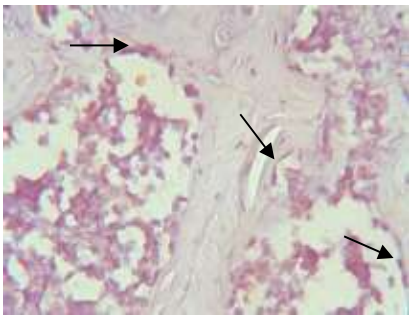

Figure 3: Apoptotic bone lining cells in high-dosage of glucocorticoids group (Sari GM, 2010)

Osteoblasts are bone-forming cells that secrete organic matrix including collagen as determining material of bone density. If osteoblasts are reduced even if lining cells as reserve cells has increased apoptosis, the process of bone formation will decrease resulting fracture risks. Other researcher stated that glucocorticoids affect bone damage

through fat embolism; vascular tamponade in caput femoral vein. Manipulation will not be able to repair cells if there is a damage or apoptosis. Likewise in bone, if the bone lining cells, reserve cells ('resting cells of osteoblasts'), are reduced due to an increase of apoptosis process, the bone formation process will decrease with decreasing bone density that causes fracture risk.

CONCLUSION

The research that has been done can be a warning to the importance of the concept of exercise dosage control for health. Everyone or athlete has different abilities that cannot be forced or generalized. This fact is often overlooked because of the demands of target. Therefore, exercise dosage arrangements need to be examined individually and put it in the best effort in order not to cause a counterproductive situation toward added value expected from physical exercise.

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