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## INFLUENCE OF TAE BO EXERCISE ON BONE MARKERS AND FRAX SCORE

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### ABSTRACT

In recent times, osteoporosis has taken epidemic proportions. It is a disorder that in time of industrialization and application of new technologies is starting to impact even the younger population. The use of modern devices in everyday life is resulting in a reduce level of human physical activity, consequently leading to inactive way of life and increase in number of people suffering from osteoporosis. Going beyond its educational character, this dissertation also has an aim to point out potential positive aspects of Tae Bo exercises on people with osteoporosis and potential positive effect on bone mass, lowering of FRAX score and better quality of life.

The study included 92 patients with osteoporosis diagnosis, who at the beginning and at the end of the study carried out laboratory blood, urine, densitometry tests and filled out questionnaires of the ten-year risk of fracture (FRAX) and Quality Questionnaire QUALEFFO 31. The study was prospective, randomized controlled study conducted on a group of women between 55 and 65 years age during the period from 01.07.2018. to 01.07.2019. Research has shown that programs Tae Bo exercise can positively impact the greater bone mass and quality of life of people with osteoporosis. Considering the social and economic magnitude and the breath of osteoporosis as a global and widespread problem, the main contribution of this study was to find new ways in mitigating the effects.

**Keywords:** osteoporosis, quality of life, Tae Bo exercises

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## Introduction

Osteoporosis as a disease is as old as humankind. One could argue that it is a state linked to age, gender, lifestyle and food intake<sup>1</sup>. Osteoporosis is a wellness, social, economical and medical issue. World Health Organization recognized osteoporosis as an emerging issue 20 years ago and devoted 2000-2010 as a decade of fight against the disease<sup>2</sup>. In that period and on initiative from WHO, a number of the world leading experts made large research contributions in finding solutions in improving prevention, diagnosis and treatment in order to reduce the number of people affected. WHO defined osteoporosis in 1994. as a metabolic rheumatoid bones disease, which exhibits itself in reduced bone mass and changes in micro-architecture of bones<sup>3</sup>.

The repercussions from osteoporosis are significant because they represent a medical and a social problem, and the cost of treating fractures requires significant economic expenditures<sup>4</sup>. Falls and injuries caused by falls (e.g. fractures) are a growing problem for people in the third age group. Injuries and fractures cause pain, functional disability, which consequently diminish the quality of life. The consequences increase costs of health care and cause mortality<sup>5</sup>. The research by Johnell and his associates estimates that about \$19 billion was spent on treating osteoporotic fractures of hip and vertebrae in the United States in 2005., and that it is expected that the bill will increase to approximately \$25.3 billion by 2025<sup>6</sup>. Studies show that exercising and eating foods rich with calcium significantly lowers risk from osteoporosis and fractures and for now is considered the most effective prevention method<sup>7</sup>.

## What is TAE BO?

Tae Bo is designed as a combination of various types of aerobics, martial arts and cardio exercises aiming to strengthen the muscles, improve heart function and act positively on mental functions. Moreover Tae Bo has a

positive influence on blood pressure regulation and on achieving better heart rate. It helps with bone mass increase which consequently leads to prevention of osteoporosis. One positive side of this type of exercise program is that it is highly adaptable with respect to the pace and the strength of the exercises to meet the needs of a group or an individual.

## Methods and materials

The study was attended by 92 respondents, divided into the test study group A (46 subjects) and the control group B (46 subjects).

The test group (group A) consisted of subjects who were on medication therapy and were taking vitamin D capsules for at least a year as part of their osteoporosis treatment. They were also performing Tae Bo exercises. The subjects conducted the exercises three times a week for 45 minutes, under supervision of a medical professional with a degree of Master of Physiotherapy who was also taught Tae Bo. In order to better monitor group (A) during their practices, the participants were divided into three smaller groups (a group counted 15, the other 16 respondents and the third 15 respondents). Each group followed the same exercise program and was ran for the same duration (45 minutes). The control group (group B) exercises consisted of walks lasting 45 minutes to one hour aimed at walking the distance of about 2.5 kilometers on flat ground. The examinees walked three times a week for six months. At the beginning and the end of the study DEXAs, laboratory calcium (CA) blood and urine lab test, phosphorus (P) and vitamin D, and BMP, ALP and bone destruction markers measurements were performed in the Vukovar hospital laboratory. Based on the results of densitometry at the beginning and at the end of the study, a ten-year risk of fracture with the FRAX questionnaire was performed along with the Quality Questionnaire of the European Foundation for Osteoporosis (QUALEFFO 31 questionnaire).

The SPSS for Windows (version 20.0, SPSS Inc., Chicago, Illinois, USA) and Microsoft Excel

Statistical Analysis Tool (version 10 of Microsoft Corporation, Redmond, WA, USA) were used for statistical analysis of data. For the analysis of the results we used the following statistical methods:

For the continuous variables, the distribution symmetry was assessed by the Shapirio-Wilk test in order to see whether there was a

statistically significant deviation from the normal Gaussian distribution, while the median and interquartal range was used for the mean value and dispersion measurements.

**Results and interpretation of the obtained research values**

**Table 1. Summary of the initial and the final assessments of FRAX values in the subjects taught Tae Bo exercises (Group A and B)**

Group A	FRAX-hip				Group B	FRAX-hip		
	initial score	end score	Change in score	Change in score *		initial score	end score	Change in score
# of smokers	19 / 46				# of smokers	11 / 46		
mean	2.8	2.4	-0.38	-0.34	mean	2.8	2.6	-0.18
max	6.9	5.1	0.10	0.10	max	5.2	5.0	0.20
min	0.6	0.4	-1.80	-1.40	min	0.7	0.5	-1.20
st.dev.	1.39	1.18	0.38	0.32	st.dev.	1.32	1.24	0.24
skewness	0.79	0.57	-2.01	-1.70	skewness	0.32	0.28	-1.77
kurtosis	0.49	-0.21	4.80	3.87	kurtosis	-1.02	-0.94	6.18
<b>p-value of change in T-score</b>			<b>0.162</b>	<b>0.139</b>	<b>p-value of change in T-score</b>			<b>0.232</b>

\* outlier removed

Out of the total number of subjects in group A, 19 are smokers. At the beginning of the study, the minimum FRAX score for group A subjects ranged from 0.6 to a maximum of 6.9, while the mean FRAX score of group A was 2.8, with a standard deviation of 1.39. At the end of the research, the FRAX score values characteristics were as follows: the minimum value was 0.4 and a maximum of 5.1; with mean value of group A of 2.4 and standard deviation of 1.18.

Analyzing the initial and final data, we note a change in mean values and their corresponding standard deviations. The "p" value of the change in the mean value reads 0.162, which strictly speaking falls just short of being statistically significant (typically one requires "p" value to be below 0.10, a milder form of statistical significance, and below 0.05 in the most strict form). For a complex (multi-factor) indicator such as FRAX, which is also impacted by a number of subjective measurements, the value of 0.16 is definitely worth noting and could be considered quite a solid result (almost significant). One more

point to note is that the above FRAX analysis also includes a subject whose FRAX value is greater than 6, an outlier. If this FRAX point is excluded from the analysis, justifiable on the basis of being such an outlier within the whole sample, a p value of 0.139 is obtained. Again the result is strictly speaking not statistically significant, but it further reinforces the notion of a positive change in the ten-year risk of fracture for group A. The eliminated measurement was for a subject with the initial FRAX of 6.9 and whose FRAX score decreased by 1.8 to 5.1 (one of the best improvements in group A). It is also important to note that large deviations, asymmetry and fat-tails significantly contribute to elevating standard deviation (i.e. the measurements are more dispersed) and are therefore negative for the "p" value. As earlier indicated, the "p" value is limited to the assumption of normal distribution. This limitation is best illustrated in the previous discussion on improving the "p" value when one of the best points is taken out, the subject with FRAX of 6.9

(and the change of 1.8). So, the above criticism of the 0.162 of the "p" value as not significant should be taken with grain of salt.

The following is the summary of group B data set and the analysis of the calculated FRAX score. The group consists of 11 smokers. At the start of the study the FRAX read as: the minimum FRAX value was 0.7, the maximum 5.2, with a mean value of 2.8 and a standard deviation of 1.32. At the end of the research study the minimum FRAX value for group B was 0.5, the maximum was 5.0, while the mean value came at 2.6 with a standard deviation of 1.24. We note the changes in the minimum, maximum and the

mean value as well as in the standard deviation however the "p" values of the changes do not show any statistical significance.

Comparing the FRAX results of group A (test group) and group B (control group), strictly speaking, both groups exhibit a suboptimal level of statistical significance. However, as analyzed earlier, group A results are statistically much stronger, coming only a tad below the significance threshold. Also, when visually comparing the results, it can be seen that in group A there is definitively a positive progress, a much harder claim to make for group B.

**Table 2. Bone marker values at the beginning and end of the study group A and B**

Group A	ALP			Group B	ALP		
	initial	final	Change		initial	final	Change
# of smokers		46		# of smokers		46	
mean	48	53	5.67	mean	48	50	2.54
max	83	81	24.00	max	71	73	8.00
min	22	32	-4.00	min	27	29	-5.00
st.dev.	17	14	6.00	st.dev.	13	13	3.04
skewness	0.65	0.33	0.84	skewness	0.19	0.11	-0.54
kurtosis	-0.71	-1.00	0.57	kurtosis	-1.17	-1.11	0.17
p-value of change in T-score			0.172	p-value of change in T-score			0.201

Alcaline phosphatase (ALP) is a specific enzyme that can be an indicator of bone changes. Its typical reference values for women range from 50 to 153 U / L. At the beginning of the study the group A patients ALP distribution was as follows: a lowest value of 22 U / L, a max of 83 U / L, and a mean of 48 U / L. This indicates the average ALP value of the group to be below the lower permissible values. At the end of the study, the minimum ALP value for group A was 32 U / L, maximum 81 U / L, while the mean came at 53 U / L, with the standard deviation of 14. The change between the initial and final values of ALP certainly indicates an improvement, but due to an uneven level of improvement across the subjects of group A, the positive change did not fully reflect in the p-value. The "p" value issue is similarly disappointing for group A and group B (with group B being slightly worse).

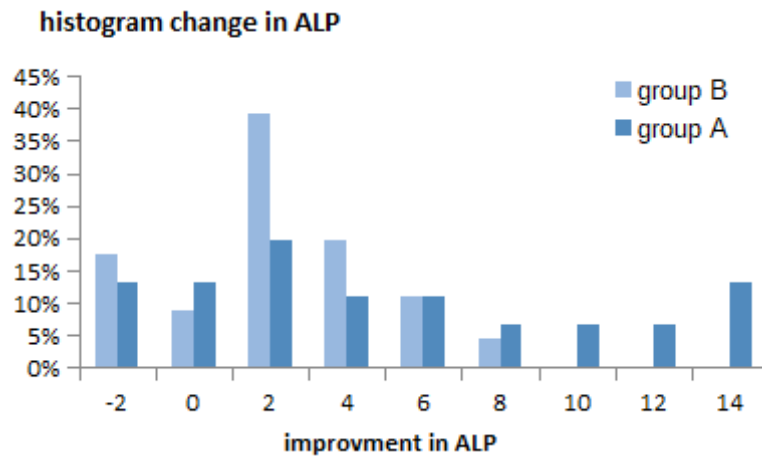
At the end of the study, the minimum ALP value for group B is 29 U / L, the maximum is 73 U / L while the mean value of the group is 50 U / L. By comparing the groups A and B results at the end of the study, it can be seen that the group subject to Tae Bo exercises have achieved better bone structure indicators than for the group who only participated in the walk program. Again, "p" values may not be the most objective indicator in for the measurements due to the "fat-right-tails", a problem more significant in the ALP improvement values for group A.

Histogram 1 compares the final values of ALP of group A and B patients. Ten percent of the group A respondents reported a decrease in ALP at the end of the study, while the same decrease in ALP was recorded in 18% of group B patients. The most noticeable change in group B was 40%, with a positive shift for two values, while



the highest increase in ALP values of 14 was observed in 12% of group A respondents. Despite the low p values in group A, the above

histogram visually shows the importance of Tae Bo's exercise for ALP (group A).



**Histogram 1. Shows ALP change among group A and B examinees at the end of the survey**

**Table 3. View of the PINP among Group A and B respondents at the beginning and end of the survey.**

Group A	PINP			Group B	PINP		
	initial	final	Change		initial	final	Change
# of smokers	46			# of smokers	46		
mean	21.19	22.34	1.15	mean	18.93	19.97	1.04
max	34.54	34.39	6.02	max	34.54	37.13	4.56
min	11.89	14.45	-4.75	min	10.09	11.17	-2.35
st.dev.	5.49	4.71	1.78	st.dev.	5.69	5.36	1.24
skewness	0.85	1.09	0.06	skewness	0.95	1.17	0.24
kurtosis	0.55	1.02	2.81	kurtosis	1.19	2.23	1.19
p-value of change in T-score	0.259			p-value of change in T-score	0.201		

N-terminal type I collagen (PINP) propeptide is the byproduct of type I collagen which is released during bone formation. Normal values for women before menopause are <of 30, while normal values in women after menopause <of 45. By analyzing initial PINP values among group A respondents, it can be observed that the minimum value of these subjects is 10.09 U / L lower than the baseline value of group B respondents. The maximum value of group A is equal to the test group, while the mean value of group A is 18.93 U / L and as such shows lower mean value than group B respondents. Also, there is a difference in standard deviation of the measurements, which at 5.69 is larger among

the control group results. Upon completion of the research, the results show that the value of the PINP of group A respondents ranges from a minimum of 11.17 U / L to a maximum of 37.13 U / L with a mean value of 19.97 U / L.

At the beginning of the study in group B, the PINP values ranged from a minimum of 11.89 U / L to a maximum of 34.54 U / L and the mean value of the group was 21.19 U / L with a standard deviation of 5.49. After the completion of the research the values of the PINP changed slightly so that the minimum value was 14.45 U / L and a maximum 34.39 U / L with a mean value of 22.34 U / L with a standard deviation of 4.71. Although there is a mild increase in PINP, an

indicator of bones reconstruction, the "p" value as such does not show any statistical significance. By comparing the "p" values of the A and B groups, the value of "p" of 0.201 does

not exhibit statistical significance, but as such it is a better result of the change than the one obtained as the "p" value of the group B.

**Table 4. Display of initial and final values of  $\beta$ -CROSSLAPS of group A and B respondents**

Group A	$\beta$ -CROSSLAPS			Group B	$\beta$ -CROSSLAPS		
	initial	final	Change		initial	final	Change
# of smokers	46			# of smokers	46		
mean	0.62	0.46	-0.16	mean	0.51	0.43	-0.08
max	1.24	1.09	0.25	max	1.06	1.01	0.21
min	0.12	0.11	-0.67	min	0.18	0.11	-0.57
st.dev.	0.37	0.31	0.21	st.dev.	0.32	0.30	0.14
skewness	0.14	0.67	-0.71	skewness	0.73	0.94	-1.55
kurtosis	-1.69	-0.92	0.27	kurtosis	-1.15	-0.61	4.40
p-value of change in T-score	0.230			p-value of change in T-score	0.295		

Normal values for this bone marker for women in menopause are from 0.10 to 1.000. The initial values of this degradation marker range from a minimum of 0.12 to a maximum of 1.24. The mean value in group A patients is 0.62 with a standard deviation of 0.37. The final results showed, minimum values of 0.11  $\beta$ -CROSSLAPS were found in Group A, up to a maximum of 1.09, with a mean value of 0.46 and a standard deviation of 0.31. By analyzing the change in the initial and final values of group A, it can be concluded that there is a positive progress in the sense of reducing the value of the bone marking construction, although the "p" value of 0.230 is not statistically significant. By examining the initial values of  $\beta$ -CROSSLAPS it can be seen that the minimum value of 0.18 is higher than the minimum value of group A, while the maximum value of  $\beta$ -CROSSLAPS among group B is 1.06 and as such is lower than those in the test group. The final value of bone loss degeneration ranges from minimum 0.11 to maximum 1.01; with a rise in the value of a group of 0.43 and a standard deviation of 0.30. Final minimum values for both groups are equal, but group A respondents have higher maximum score as well as higher mean values. Although there is a positive change in terms of bone degradation reduction in both groups "p" the B

group value of 0.295 is not statistically significant.

### Discussion

The study included 92 patients with osteoporosis diagnosis and initial T values ranged from -4.5 to -2.5. The subjects were divided into two groups, where group A patients had been subject to six months of Tae Bo exercise while group B patients were subject only to walk exercises. At the end of the study, a densitometry was established to determine that the group A had a positive improvement in terms of observed improved bone density in 40% of the subjects by 0.2, and observed better value of the hip T-score in 40% of the subjects by better than 0.3; compared to those who were walking. In group B respondents, the value of the hip T-score is also better, but the difference between the initial and the final values does not represent a statistically significant change. Contrary to these results, the initial and final values of the spinal T-score showed much less progress in both groups, so the A-group respondents had an improvement in T-score at the end of the study: 44% by 0.2, while 20% for an improvement of 0.1.

One of the possible reasons why T score of spine among group A patients did not show

better results is precisely the relatively short period of research. It is inevitable to point out that it is an extremely important way to access physical activity in people with osteoporosis, and this is just a research. Group A examiners performed Tae Bo exercises that were tailored to address the problem of osteoporosis and muscle strength and parts of the locomotor system that are most often affected by osteoporosis. It is therefore important to emphasize that physical activity is a factor that is very important in treating osteoporosis. The relationship and influence of physical exercise to reducing the risk of osteoporosis and the correlation of bone mass improvement in people who regularly exercise physically say numerous researches such as research by Shaw and Associates<sup>8</sup>. Physical exercises should adapt to the age and health status of the person, and trainings should certainly be oriented towards strengthening the muscle groups with the most common fractures. In this way, the exercises carried out by group A participants were designed. Exercises are recommended for individuals with loads that are, however, a bit higher than those on performing daily activities<sup>9</sup>. A review of the literature reveals the lack of published papers on the correlation of certain exercise modes and their impact on bone mass as well as the impact on the quality of life of people with osteoporosis.

For the purpose of this study, FRAX was used to estimate the ten-year risk of fracture in the hip area, given that the mean age of the examinees was 63.1 years when the hip fractures are most commonly observed<sup>10</sup>. Numerous studies indicate smoking hazards, and a bad nicotine effect on estrogen and testosterone functioning, resulting in lower calcium in bone and higher chance of osteoporosis. Among the survey respondents, 92 of them, there were 30 respondents who were smoking. Out of these, 19 were group A and 11 were group B. By computing the FRAX questionnaires for each individual patient, and analyzing the data, it could be seen that if the person smokes, he has

a significantly greater ten-year risk of fracture than the same or similar value in a person who is a non-smoker.

In this study, a FRAX questionnaire was conducted and analyzed among respondents who were divided into test and control group. The results showed that there was a better progress in the group subject to Tae Bo exercises in terms of reducing the ten-year risk of fracture, although the "p" value that resulted from the analysis of the change between the initial and the final results is not statistically significant. However, since that conclusion is based on the FRAX score of the whole group A, it has to be emphasized that a large number of smokers influenced the result, as in the group A there were almost twice as many persons smoking than in the group B. The final values of the FRAX of group B respondents were expected to be worse. Although in this group as well there is a positive progress in reducing risk of fracture, the "p" value of this group does not show any statistical significance. For the purposes of this study, ALP, PINP and  $\beta$ -CROSSLASS were analyzed as well. The first two bone markers are indicators of bone building and as such show the usefulness of treatment for six months from the beginning of the therapy. The study showed that among the respondents who had very different, but in principle low values of ALPs (which are far below normal levels) a positive shift in both groups can be observed at the end of the study. A slightly better "p" value indicates the better results for the group subject to Tae Bo. The result is not sufficiently strong to be statistically significant, but certainly more significant than the "p" values of group B respondents. Similar results came from a group of French researchers Maimouna and associates who monitored changes in ALP values that occurred in subjects who conducted an intense fitness program until the values of 25 (OH) D were significantly altered (126). PINP as a bone marking constructor has also been analyzed in the research. Just like the ALP values, neither the PINP values show

statistically significant change in either group although the results of group A respondents are slightly better than those of group B.  $\beta$ -CROSSLAPS is a bone marker indicating bone breakdown. In biochemical analyzes, after two months of therapy, it may be helpful to see if the drugs are effective. The bone marking breakdown in this study did not show a statistically significant change as expected. The results of the study showed that there was a somewhat greater reduction in bone destruction among Tae Bo (group A) subjects than those who were walking (group B respondents). Since Tae Bo exercises have elements of dancing, aerobics and martial arts and are as intensive as aerobic and aerobic, the results of these studies can be compared. If the results of research related to the level of bone markers compared with those surveyed by Tae Bo with the results of Anek's survey where aerobic and aerobic exercise subjects were examined, it can be seen that they are similar to the results of BMP bone markers and bone loss degeneration  $\beta$ -CROSSLAPS, points out the difference in how Anek's and associates' research was conducted on working healthy women aged 35-40 years, whereas the research that was conducted for the purpose of writing this dissertation was done on a group of women with osteoporosis who were age of 55-65 years<sup>11</sup>.

According to a survey conducted in Thailand among female employees looking for aerobic exercise on a soft and hard substrate and their effect on bone markers, it has been shown that people who have been on a hard surface have better results when it comes to PINP and  $\beta$ -CROSSLAPS, which is in favor of Tae Bo exercises that are carried out on tatami substrates in order to gain strength and stability in motion<sup>12</sup>.

## Conclusion

Research has shown that programs Tae Bo exercise can positively impact the greater bone mass and quality of life of people with osteoporosis. Considering the social and economic magnitude and the breath of

osteoporosis as a global and widespread problem, the main contribution of this study was to find new ways in mitigating the effects.

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