Journal of Health Sciences

RESEARCH ARTICLE Open Access

Relationship between lifestyle habits of postmenopausal women and altered bone mineral density determined by ultrasound (US) screening and dual energy X-ray absorptiometry (DEXA)

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ABSTRACT

Introduction: Osteoporosis is a skeletal system disease characterized by decline of bone mass and deterioration of bone microarchitecture, which leads to increased bone fragility and, consequently, a greater risk of fractures. Postmenopausal osteoporosis generally occurs between 51 and 75 years of age following ovarian failure. Our aim was to investigate if specific lifestyle habits, i.e., smoking cigarettes and physical activity, as well as the intake of dietary supplements, affect bone mineral density (BMD) in postmenopausal women.

Methods: Ultrasound (US) and dual energy X-ray absorptiometry (DEXA) data, obtained between 2008 and 2009 year, were retrospectively reviewed for 150 women in postmenopause, 50-65 years old, who live in Sarajevo Canton. The women were classified into two groups: Group A (75 postmenopausal women who underwent US of the left heel bone); control group B (75 postmenopausal women who underwent US of the left heel bone and had a DEXA scan of the lumbar spine and left hip).

Results: The study included 150 women with the average age of 55.39 years. In the total sample, 24.7% of women took calcium and vitamin D supplements, and no statistically significant difference was observed between the groups. In the total sample, the prevalence of osteoporosis was significantly different between smokers and nonsmokers; i.e., osteoporosis was more frequent in women who smoked cigarettes. On average, women in both groups reported low physical activity; the difference was not statistically significant.

Conclusions: Menopause is a known risk for osteoporosis. Our results showed that the length of menopause is closely associated with osteoporosis occurrence.

Keywords: Osteoporosis; lifestyle habits; menopause; menopause length; ultrasound; DEXA scan

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Submitted: 10 February 2017/Accepted: 8 March 2017

DOI: https://doi.org/10.17532/jhsci.2017.446

INTRODUCTION

Osteoporosis is a condition characterized by a decrease in the density of bone and changes in trabecular bone microarchitecture, and it results in bone fragility as well as an increased risk of bone fractures (1,2). It is a very common disease affecting

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over 75 million people in Europe, Japan, and the United States [U.S.] (3). According to The Surgeon General's Report on Bone Health and Osteoporosis from 2004, one in two Americans will have, or be at high risk of developing osteoporosis of the hip or other bones, in 2020 year (4). In 2003, 7.8 million of Germans (6.5 million of women) suffered osteoporosis (5).

Although there are no symptoms at the early stages, bone microfracture and skeletal deformities in osteoporosis may cause chronic pain and disability at later stages. This condition is associated with different clinical characteristics, but it is mostly related to aging and menopause. The prevalence of postmenopausal osteoporosis accounts for the overall female-male ratio of 2:1 to 3:1. Approximately 25% of women experience bone fracture at the age of 65 years, and around 50% at the age of 90 (2,6). Women have 30% lower bone mineral density (BMD) in their eighties compared to the measurements in the third decade of life (7). Among the causes of osteoporosis are also some medications, including glucocorticoids, anticonvulsants, antiepileptic drugs, inhibitors of proton pump, retinoids, and others (8). Also, during inflammation, activated T lymphocytes can contribute to increased bone resorption, by producing pro-inflammatory cytokines that affect the biological activity of the bone cells (9). Osteoporosis-related fractures frequently occur in older women, and estrogen deficiency is associated with secondary osteoporosis. In addition, estrogen deficiency leads to increased production of pro-inflammatory cytokines by T lymphocytes, including TNF-α, IL-1, IL-6, IL-7, and IL-8 (9-11).

Long-term excessive alcohol consumption is a risk factor for decreased BMD, as well as low calcium and other nutrient intake, decreased body weight, cigarette smoking, and high caffeine intake (12). The biologically active form of vitamin D promotes calcium absorption in the small intestine and calcium reabsorption in the kidneys (13). Vitamin D deficiency leads to decreased absorption of calcium and phosphorus which, in turn, increases the production of parathyroid hormone (PTH); a condition known as secondary hyperparathyroidism. Due to PTH overproduction, and in order to maintain constant level of calcium in the blood, calcium is removed from the bones into the blood. In addition, renal excretion of phosphorus is increased. The direct consequence of these processes is decreased bone mineralization (low BMD) and the development of osteopenia or osteoporosis (14). In their review, del Ghianda et al. (15) discussed the relationship between menopause and thyroid function and the combined effect on the reduction of BMD (15).

A considerable amount of financial resources is appropriated for the treatment of osteoporosis and osteoporotic fractures. In Germany, the treatment of hip fractures only, imposes an annual economic burden of €3 billion; in the United Kingdom (U.K.) this figure is estimated at £1.7 billion, which severely burdens the healthcare systems in these countries (4,16). According to a study from 2010, 3.5 million of osteoporosis-related fractures were registered in European Union (EU) countries [17.7% of hip fractures and 14.8% of spine fractures] (17). In the U.S., the prevalence of osteoporosis-related fractures is estimated at 1.5 million annually (18).

Osteoporosis can be classified as primary or secondary osteoporosis. Primary or involutional osteoporosis is the more common form and the etiology is unknown. There are two types of primary osteoporosis, type 1 and type 2. Type 1 osteoporosis occurs frequently in postmenopausal women (known also as postmenopausal osteoporosis). Type 2 or senile osteoporosis is prevalent in the elderly (19). Type 3 or secondary osteoporosis occurs in both sexes at any age and is associated with different causes, including endocrine disease and genetic abnormalities (1,20,21). Finally, idiopathic osteoporosis can affect juveniles, premenopausal women, and middle-aged men.

Postmenopausal osteoporosis occurs in women 15 to 20 years of menopause. Fractures are evident in trabecular bone, usually in the distal forearm and vertebrae. These women also have estrogen deficiency (22) which increases bone remodeling and thus affects the balance between bone formation and bone resorption, i.e. bone resorption is increased (23,24). After menopause, urinary excretion of calcium is elevated and the inhibition of bone resorption associated with PTH release is lowered, which leads to increased loss of BMD (2,25). In addition, a study showed differences in the prevalence of osteoporosis and risk of fractures between

different racial groups and inside every group (26). Furthermore, considerable variation in the incidence of fractures between several countries indicates the importance of environmental factors in osteoporosis-related conditions (2).

The aim of this study was to investigate if specific lifestyle habits, i.e., smoking cigarettes and physical activity, as well as the intake of dietary supplements, affect BMD in postmenopausal women, aged between 50 and 65 years, and who live in Sarajevo Canton. We also assessed the difference in the effect of these factors on BMD between the postmenopausal women with normal menstrual history and those with estrogen deficiency.

METHODS

Study groups

A total of 150 women in postmenopause, 50-65 years old, who live in Sarajevo Canton were included in the study. The women were classified into two groups:

1. Group A (75 postmenopausal women, aged between 50 and 65 years, who underwent ultrasound [US] of the left heel [calcaneus] bone).
2. Control group B (75 postmenopausal women, aged between 50 and 65 years, who underwent ultrasound [US] of the left heel [calcaneus] bone and had a dual energy X-ray absorptiometry [DEXA] scan of the lumbar spine and left hip).

US examination and DEXA scan

The US data of the left heel bone obtained at the health practitioner's office "AD" and DEXA scans of the lumbar spine (L1-L4) and left hip carried out at the Clinic for Radiology of University Clinical Center Sarajevo, between 2008 and 2009 year, were retrospectively reviewed for 150 postmenopausal women.

The DEXA scans were performed on a Hologic QDR-4000 (S/N 55680) scanner (General Electric, Milwaukee, USA). The results are reported as T scores which represent the number of units (standard deviations) that the bone density of a patient is above or below the average result (i.e. ,what is normally expected in a healthy young person of the same sex).

Questionnaire

The questionnaire on clinical data of the participants included the following information:

- General information (name and surname, sex, birth year, living address);
- Menstrual history (menarche and menopause);
- Lifestyle habits (cigarette smoking and physical activity);
- Dietary supplement intake (calcium and vitamin D3 supplements);
- Medical records of diseases that cause osteoporosis;
- Medical records of medications that cause osteoporosis.

Statistical analysis

Based on the questionnaire, we analyzed the differences in daily calcium intake through supplements, cigarette consumption and physical activity between Group A and B (control) in relation to the menstrual history of women (i.e. normal or with estrogen deficiency).

The results were grouped according to defined parameters and presented using descriptive and inferential statistics. Two major groups were defined: Case and control group; then, both groups were further classified according to different parameters. Descriptive statistics included: The number of cases, percentage, average value, standard deviation (SD), and standard error of the mean (SEM), while inferential statistics comprised of the results of hypothesis testing, degree of freedom, and statistical significance. For non-parametric data (frequencies) differences between groups were tested by Chi-square test and for parametric data Student's *t*-test was used. The relationship between variables was assessed by correlation analysis.

RESULTS

A total of 150 women between 50 and 60 years old (average age 55.39 years) participated in this study. A statistically significant difference in the average age was observed between Group A and B

[Student's t test$_{(143)}$ = -3.843; $p < 0.0001$ (Table 1)]; furthermore, additional medical examinations were more frequently carried out in older women. The women from group B also had statistically longer average length of menopause compared to Group A (t = -2.983; p = 0.003; Table 2).

On average, women in both groups reported low physical activity; the difference was not statistically significant (X^2 = 0.048; $p \geq 0.05$; Table 3). The following results also showed no significant difference between Group A and B: Number of smokers (X^2 = 2.218; $p > 0.05$; Table 4); Ca and vitamin D supplementation (X^2 = 2.296; $p > 0.05$; Table 5); in the total sample, 24.7% of women took calcium and vitamin D supplements; therapy for other chronic diseases ($X^2_{(3)}$ = 2.883; $p > 0.05$; Table 6); in the total sample, most women (86.7%) did not receive additional therapy; and the number and type of fractures ($X^2_{(7)}$ = 7.927; $p > 0.05$; Table 7).

There was no significant difference in the average weight, height, and body mass index (BMI) between Group A and B (weight t = 1.353, $p > 0.05$; height t = 0.999, $p > 0.05$; and BMI t = 1.020, $p > 0.05$; Table 8).

A significantly negative correlation was observed between the length of menopause and BMD determined by the US of heel bone (Pearson correlation coefficient was -0.246; p = 0.002); longer duration of menopause resulted in decreased BMD. The correlation between BMD determined by DEXA of the hip and spine and the length of menopause was not significant (Figure 1).

Although lower BMI was observed in osteoporotic women compared to those without osteoporosis, this result was not statistically significant (t = 1.732; p = 0.085; Table 9). According to the US results for heel bone, a significant difference was observed in BMD between smokers and nonsmokers ($X^2_{(2)}$ = 6.941; p = 0.031), while significant differences were not observed for BMD determined by DEXA scans of hip and spine (for hip $X^2_{(2)}$ = 2.327; p = 0.312, for spine $X^2_{(2)}$ = 1.448; p = 0.485; Table 10).

In the total sample, the prevalence of osteoporosis was significantly different between smokers and nonsmokers (X^2 = 3.946; p = 0.047; Table 11). According the US results for heel bone, a significant difference in the rate of bone mass loss was observed between women who took calcium and vitamin D supplements and those who did not ($X^2_{(2)}$ = 7.534; p = 0.023); similar results were obtained for BMD determined by DEXA scan of spine ($X^2_{(2)}$ = 6.104; p = 0.046). On contrary, no significant difference was observed in BMD assessed by the DEXA scan of hip between women who took supplements and those who did not ($X^2_{(2)}$ = 1.374; p = 0.503). In the total sample, this difference was also not significant (Table 12). All three diagnostic methods showed no significant difference in BMD between women in

TABLE 1. Average age of women in two groups (with and without DEXA scan performed)

DEXA scan	Mean age	N	Standard deviation
Yes	53.68	75	4.930
No	57.09	75	5.928
Total	55.39	150	5.697

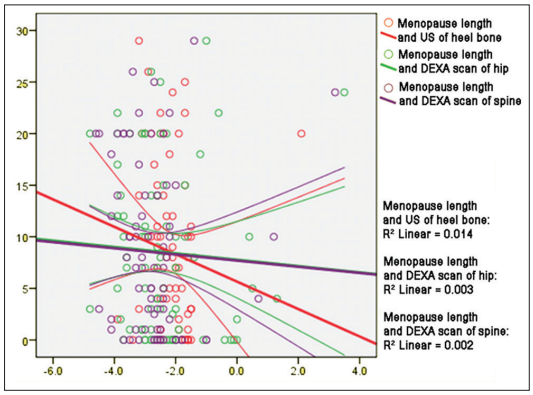

FIGURE 1. Correlation between menopause length and bone mineral density determined by ultrasound (US) and DEXA scans in postmenopausal women.

TABLE 2. Average length of menopause in two groups of postmenopausal women (with and without DEXA scan performed)

Menopause length	Groups	N	Mean±SD	Standard error of the mean
	Ultrasound	75	4.48±8.349	0.964
	Ultrasound+DEXA scan	75	8.50±8.154	0.942

SD: Standard deviation

relation to the physical activity (for the US of heel bone $X^2_{(2)} = 3.077$; $p = 0.215$; for the DEXA scan of hip $X^2_{(2)} = 0.167$; $p = 0.920$; for the DEXA scan of spine $X^2_{(2)} = 4.203$; $p = 0.122$; Table 13).

TABLE 3. Physical activity in two groups of postmenopausal women (with and without DEXA scan performed)

Physical activity	Ultrasound (%)	Ultrasound+DEXA scan (%)	Total (%)
No	63 (84.0)	62 (82.7)	125 (83.3)
Yes	12 (16.0)	13 (17.3)	25 (16.7)
Total	75 (100.0)	75 (100.0)	150 (100.0)

TABLE 4. Cigarette smoking in two groups of postmenopausal women (with and without DEXA scan performed)

Cigarette consumption	Ultrasound (%)	Ultrasound+DEXA (%)	Total (%)
No	60 (80.0)	51 (68.0)	111 (74.0)
Yes	15 (20.0)	24 (32.0)	39 (26.0)
Total	75 (100.0)	75 (100.0)	150 (100.0)

DISCUSSION

In the total sample, the average age was 55.39 years. In a study on 836 women, Hadžiavdić et al. (27) showed the average age of 52.6 years, which is in agreement with our results.

We showed that out of 150 women, 24.7% took calcium and vitamin D supplements and the difference in BMD was not significant between women who took the supplements and those who did not ($X^2 = 2.296$; $p > 0.05$). In the study of Kapetanović et al. (28), among 60 women, 56.66% did not take the recommended daily amount of calcium (28).

Lips et al. (29) investigated types of patients who may benefit from calcium and vitamin D supplementation; the authors reported that in the case when patient compliance was moderate or less, the benefits of supplements were not visible, especially in terms of fracture prevention (29). Among

TABLE 5. Calcium+Vitamin D3 supplement intake in two groups of postmenopausal women (with and without DEXA scan performed)

Calcium+Vitamin D3 supplementation	Ultrasound (%)	Ultrasound+DEXA scan (%)	Total (%)
No	61 (81.3)	52 (69.3)	113 (75.3)
Yes	14 (18.7)	23 (30.7)	37 (24.7)
Total	75 (100.0)	75 (100.0)	150 (100.0)

TABLE 6. Intake of medication for other diseases among postmenopausal women in two groups

Medication use	Ultrasound (%)	Ultrasound+DEXA scan (%)	Total (%)
No	68 (90.7)	62 (82.7)	130 (86.7)
Corticosteroids	1 (1.3)	2 (2.7)	3 (2.0)
Thyroid hormone replacement	3 (4.0)	3 (4.0)	6 (4.0)
Other	3 (4.0)	8 (10.7)	11 (7.3)
Total	75 (100.0)	75 (100.0)	150 (100.0)

TABLE 7. Type and prevalence of fractures among postmenopausal women in two groups

Bone fracture	Ultrasound (%)	Ultrasound+DEXA scan (%)	Total (%)
None	62 (82.7)	55 (73.3)	117 (78.0)
Forearm	2 (2.7)	5 (6.7)	7 (4.7)
Spine	0 (0.0)	2 (2.7)	2 (1.3)
Hip	0 (0.0)	2 (2.7)	2 (1.3)
Other	10 (13.3)	8 (10.7)	18 (12.0)
Spine and forearm	1 (1.3)	1 (1.3)	2 (1.3)
Spine and other	0 (0.0)	1 (1.3)	1 (0.7)
Forearm and other	0 (0.0)	1 (1.3)	1 (0.7)
Total	75 (100.0)	75 (100.0)	150 (100.0)

TABLE 8. Average values of body mass index (BMI), weight, and height among postmenopausal women in two groups

Parameter	Diagnostic method	N	Mean±SD	Standard error of the mean
BMI	Ultrasound	75	26.272±3.8845	0.4485
	DEXA scan+Ultrasound	75	25.647±3.6175	0.4177
Weight	Ultrasound	75	71.80±10.418	1.203
	DEXA scan+Ultrasound	75	69.41±11.170	1.290
Height	Ultrasound	75	165.93±6.725	0.777
	DEXA+Ultrasound	75	164.88±6.171	0.713

SD: Standard deviation

TABLE 9. Body mass index (BMI) in postmenopausal women in relation to bone mineral density (BMD) determined by ultrasound (US) and DEXA scans

Diagnostic method/Diagnosis	US of heel bone	DEXA scan of hip	DEXA scan of spine
	Average BMI	Average BMI	Average BMI
Normal finding	25.964	27.874	28.220
Osteopenia	26.149	25.505	25.758
Osteoporosis	25.427	25.157	25.353
Total average	25.959	25.647	25.647

TABLE 10. Bone mineral density in relation to smoking status in postmenopausal women

Diagnostic method	Cigarette smoking	Normal finding (%)	Osteopenia (%)	Osteoporosis (%)	Total (%)
Ultrasound of heel bone	Yes	10 (25.6)	17 (43.6)	12 (30.8)	39 (100)
	No	42 (37.8)	55 (49.5)	14 (12.6)	111 (100)
DEXA scan of hip	Yes	3 (12.5)	4 (16.7)	17 (70.8)	24 (100)
	No	8 (15.7)	16 (31.4)	27 (52.9)	51 (100)
DEXA scan of spine	Yes	2 (8.3)	4 (16.7)	18 (75.0)	24 (100)
	No	3 (5.9)	15 (29.4)	33 (64.7)	51 (100)

TABLE 11. Prevalence of osteoporosis among women in relation to cigarette smoking

Diagnosis	Cigarette consumption		
	No	Yes	Total
Normal finding	74	19	93
Osteoporosis	37	20	57
Total	111	39	150

50 women with osteoporosis, Kern (30) reported that 56% of these patients daily consumed only half a liter of milk, despite being aware that milk is the best food source of calcium. Calcium supplements occasionally took 38% of patients, 36% regularly, and 26% of patients did not take the supplements (30).

Different studies showed that low BMI is a risk factor for low BMD (31). In our study, there was no significant difference in the average weight, height, and BMI between Group A and B (weight $t = 1.353$, $p > 0.05$; height $t = 0.999$, $p > 0.05$; and BMI $t = 1.020$, $p > 0.05$). Milenković et al. (23) showed that among 186 female participants, osteoporosis was more frequent in older women, with lower height and BMI, while Muftić (32) reported an average BMI of 21.13 among 100 female participants, which is in the range of normal weight (32). In the study of Kern (30), 56% of women with osteoporosis were overweight (30).

In our study, lower BMI was observed in osteoporotic women compared to those without osteoporosis, but this result was not statistically significant ($t = 1.732$; $p = 0.085$). In the study of Kapetanović et al. (28), 6.66% of women out of 60 female participants had lower BMI (28). In a study of 189 pre- and post-menopausal Irish women, Cummins et al. (33) reported that 59% of women had low BMD. Age, family history, smoking cigarettes, metabolic and mechanical lifetime physical activity, and

TABLE 12. Prevalence of osteoporosis among women in relation to calcium and vitamin D3 supplement intake

Diagnostic method	Calcium+Vitamin D3 intake	Normal finding (%)	Osteopenia (%)	Osteoporosis (%)	Total (%)
Ultrasound of heel bone	Yes	8 (21.6)	25 (67.6)	4 (10.8)	37 (100)
	No	44 (38.9)	47 (41.6)	22 (19.5)	113 (100)
DEXA scan of hip	Yes	5 (21.7)	6 (26.1)	12 (52.2)	23 (100)
	No	6 (11.5)	14 (26.9)	32 (61.5)	52 (100)
DEXA scan of spine	Yes	4 (17.4)	5 (21.7)	14 (60.9)	23 (100)
	No	1 (1.9)	14 (26.9)	37 (71.2)	52 (100)

TABLE 13. The effect of physical activity on bone mineral density in postmenopausal women determined by ultrasound (US) or DEXA scans

Diagnostic method	Physical activity	Normal finding (%)	Osteopenia (%)	Osteoporosis (%)	Total (%)
US of heel bone	Yes	6 (24.0)	16 (64.0)	3 (12.0)	25 (100)
	No	46 (36.8)	56 (44.8)	23 (18.4)	125 (100)
DEXA scan of hip	Yes	2 (15.4)	4 (30.8)	7 (53.8)	13 (100)
	No	9 (14.5)	16 (25.8)	37 (59.7)	62 (100)
DEXA scan of spine	Yes	0 (0.0)	6 (46.2)	7 (53.8)	13 (100)
	No	5 (8.1)	13 (21.0)	44 (71.0)	62 (100)

weight accounted for 39% of the variance in lumbar BMD in these women (33).

Our results showed no significant difference in the number of smokers between the women with osteoporosis and those without osteoporosis ($X^2 = 2.218$; $p > 0.05$), and this result is not in correlation with other studies. For example, Kapetanović et al. (28) showed 63.33% of smokers in a sample of 60 women, while 64% of women were smokers in the study of Kern (30). Kanis et al. (3) reported that smoking cigarettes was significantly associated with higher risk of fractures [relative risk (RR) = 1.25; with 95% confidence interval (CI) = 1.15-1.36)] (3). In a 5-year longitudinal study, Rudäng et al. (34) showed a negative effect of smoking on BMD (34).

According to Fini et al. (35), overweight and obesity protect bone and reduce the risk of fracture and the development of osteoporosis in older adults. On contrary, extreme obesity (BMI >40 kilogram/meter squared) appears be a risk factor for osteoporosis. Similarly, moderate alcohol consumption may have a protective effect, but excessive alcohol consumption leads to reduction in BMD. The authors also indicated smoking as risk factor for osteoporosis, by interfering with estrogens, calcium and vitamin D (35).

Low physical activity is a risk factor for osteoporosis due to its effect on bone remodeling and resorption (36). It is also associated with a decrease in the mass of muscles, which leads to insecure walking and frequent falls. In our study, women in both groups reported, on average, low physical activity, with no statistical difference between the two groups ($X^2 = 0.048$; $p \geq 0.05$). In a sample of 350 female participants, Avdić and Kapetanović (37) showed that 229 of women did not have any physical activity (37). Kapetanović et al. (28) reported 33.33% (total sample of 60) women with low physical activity (28).

In our study, all three diagnostic methods showed no significant difference in BMD between women in relation to the physical activity (for the US of heel bone $X^2_{(2)} = 3.077$; $p = 0.215$; for the DEXA scan of hip $X^2_{(2)} = 0.167$; $p = 0.920$; for the DEXA scan of spine $X^2_{(2)} = 4.203$; $p = 0.122$). Among 30 postmenopausal women with osteoporosis, Aksentić et al. (24) reported 86% of those with inadequate physical activity (24).

Bidoli et al. (26) carried out a study on 1373 women in the North-East of Italy. They investigated physical activity for three specific periods of life in this population, and indicated that past and recent physical activity leads to increased BMD in middle-aged

women (26). In the study of Kern (30), 56% of women were not physically active and 44% of them reported occasional or recreational physical activity (30). Other studies showed positive effects of physical activity on BMD (38,39).

In our study, no significant difference was observed in the number and type of fractures between women with and without osteoporosis ($X^2_{(7)} = 7.927$; $p > 0.05$).

CONCLUSION

The following are the highlights from our study: The average age of women in this study was 55.39 years. Irregular menstrual cycle was more common in women with osteoporosis. The length of menopause was significantly associated with osteoporosis. Women with osteoporosis had more frequently low BMI (underweight). A significantly higher number of smokers was in the group of women with osteoporosis. Calcium and vitamin D supplement intake was not significantly associated with higher BMD in our sample. Both groups of women showed low physical activity.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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