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The efficacy of Radial and Focused Extracorporeal Shock-Wave Therapies in the Treatment of Subacute Coccydynia According to Age and Body Mass Index

Radyal ve Odaklı Ekstrakorporeal Şok-Dalga Terapilerinin Subakut Koksidini Tedavisinde Yaşa ve Vücut Kitle İndeksine Göre Etkinliği

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Abstract

Introduction: The aim of this study is to investigate the effects of Radial Extracorporeal Shock Wave Therapy (r-ESWT) and Focused ESWT (f-ESWT) methods in the treatment of subacute coccydynia according to age and BMI.

Materials and Methods: Sixty patients were randomized into the three ESWT groups (Radial, Focused, Sham). All patients were evaluated with Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) before treatment, right after 4 sessions of treatment (4 weeks), 1 month after the end of treatment (8th week), and 3 months after the end of treatment (16th week).

Results: Compared with baseline, the mean VAS scores of patients aged 18-35 showed a statistically significant decrease in the 4th week only in r-ESWT group. VAS scores at week 16 in the 18-35 age range decreased more in the r-ESWT group than in the f-ESWT group. The 16th week ODI scores decreased more in the r-ESWT group than in the f-ESWT group at the ages of 18-35, and in the f-ESWT group at the ages of 36-50 compared to the r-ESWT group. While VAS and ODI scores at week 16 decreased more in the r-ESWT group in normal weight patients, these two scores decreased more in the r-ESWT group in overweight/obese patients at the same week.

Conclusion: The r-ESWT could be preferable in the ages of early adulthood (18-35) and normal weight patients (BMI <25) and the f-ESWT could be preferable in the ages of middle adulthood (36-50) and overweight/obese patients (BMI ≥25) in the treatment of coccydynia.

Keywords: Coccyx; shock wave therapies; randomized controlled trial; body mass index; age factor.

Özet

Amaç: Bu çalışmanın amacı, subakut koksidini tedavisinde radyal Ekstrakorporeal Şok Dalga Tedavisi (r-ESWT) ve focused/odaklı ESWT (f-ESWT) yöntemlerinin etkilerini yaşa ve vücut kitle indeksi (VKİ)'ne göre araştırmaktır.

Gereç ve Yöntem: Altmış hasta, üç ESWT grubuna (r-ESWT, f-ESWT, Sham ESWT) randomize edildi. Tüm hastalar tedavi öncesi, 4 seans tedaviden hemen sonra (4. hafta), tedavi bitiminden 1 ay sonra (8. hafta) ve tedavi bitiminden 3 ay sonra (16. hafta) Görsel Analog Skala (VAS) ve Oswestry Engellilik İndeksi (ODI) ile değerlendirildi.

Bulgular: 18-35 yaş arası hastaların ortalama VAS skorları tedavi öncesi ile karşılaştırıldığında, sadece Radial ESWT grubunda 4. haftada istatistiksel olarak anlamlı düşüş gösterdi. 18-35 yaş aralığında 16. haftada VAS skorları r-ESWT grubunda Odaklı ESWT grubuna göre daha fazla düşüş göstermiştir. 16. hafta ODI skorları; 18-35 yaş aralığında r-ESWT grubunda f-ESWT grubuna göre daha fazla, 36-50 yaş aralığında ise f-ESWT grubunda r-ESWT grubuna göre daha fazla düşüş göstermiştir. Normal kilolu hastalarda 16. haftadaki VAS ve ODI skorları r-ESWT grubunda daha fazla düşerken, aynı haftada aşırı kilolu/obez hastalarda bu iki skor f-ESWT grubunda daha fazla düşüş göstermiştir.

Sonuç: Koksidini tedavisinde; r-ESWT erken erişkinlik döneminde (18-35 yaş) ve normal kilolu hastalarda (VKİ <25) tercih edilebilir, f-ESWT ise orta erişkinlik döneminde (36-50 yaş) ve aşırı kilolu/obez (VKİ ≥25) hastalarda tercih edilebilir.

Anahtar Kelimeler: Koksiks; şok dalga tedavileri; randomize kontrollü çalışma; vücut kitle indeksi; yaş faktörü.

Introduction

Coccydynia describes the pain around the coccyx (1). It is exacerbated by prolonged sitting, standing up from sitting position, defecation and sexual intercourse. It is a predominantly female gender and adult age disease and less common in men and in childhood (2). Most patients with coccidynia have a history of trauma in etiology. However, coccydynia may also occur due to pathological entities such as chordoma, giant cell tumor, intradural schwannoma, perineural cyst, intraosseous lipoma and infection in this region (3). Conservative options in the treatment of coccydynia include; seat cushion, oral non-steroidal anti-inflammatory drugs, massage, stretching, physical therapy, steroid injections, radiofrequency treatments (RFT), ganglion blocks and, extracorporeal shockwave therapy (ESWT)

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(4). In cases unresponsive to conservative treatments, partial or complete resection of the coccyx is surgically performed (5). Extracorporeal Shock Wave Therapy (ESWT) is a treatment method based on high amplitude sound waves focusing on the desired area of the body and providing treatment there (6). After being used for the first time in the treatment of kidney stones in urology in the 1970s, it is increasingly preferred in the treatment of musculoskeletal disorders (7). ESWT application is used in two different wave types in the treatment of musculoskeletal disorders; Radial and Focused. These two wave types have different electro-physical properties when compared to each other. These different electrophysical properties affect the pressure increase rates during application and the maximum depth they can reach within the tissues (8). In Focused ESWT, the pressure increases rapidly and the tissue depth that the waves can reach up to 12 cm. In radial ESWT, the pressure increases more slowly and the waves can reach a maximum depth of 3-4 cm (9-11). Since the first contact with the probe occurs with the skin and subcutaneous tissues in the area where ESWT will be applied, it is a fact that the changes in these tissues according to age and body mass index have the potential to change the treatment result (12,13). Both the difference in electrophysical properties of the two ESWT wave types and the fact that the tissue properties from the skin to the target tissue (subcutaneous tissues, muscles and bones) vary according to age and weight, may contribute to obtain different results in the shock wave treatment of coccydynia. In this context, choosing between the two types of ESWT (r-ESWT or f-ESWT) based on age and weight (body mass index) may provide more effective treatment outcomes than a random selection. Although ESWT has been applied previously as an option in the treatment of coccydynia (14-18), no studies were found about comparing these two different types of ESWT. Therefore, in this pilot study, we tried to present the treatment results of r-ESWT and f-ESWT in the treatment of coccydynia according to age and body mass index in order to make a different contribution to the literature.

Materyal and Method

Participants: A total of 60 patients were included in the study. f-ESWT has been applied to 20 patients, r-ESWT to 20 patients, and Sham ESWT to 20 patients. General descriptive statistics of demographic variables are shown in table 1.

Table 1: General descriptive statistics of the demographic variables

		Mean	Standard Deviation	Min-Max	*p.
Age		35.92	12.02	18.0-65.0	
BMI (kg/m²)		26.21	3.00	19.9-31.6	
Disease Duration (week)	Focused	8.15	1.69	6-12	
	Radial	9.15	1.98	5-12	0.092
	Sham	8.00	1.62	5-11	
		N	%		
Gender	Female	50	83.3		
	Male	10	16.7		
Type of ESWT	Focused	20	33.3		
	Radial	20	33.3		
	Sham	20	33.3		

BMI: Body Mass Index **ESWT:** Extracorporeal shock wave therapy **VAS:** Visual Analogue Scale
***** Significance levels according to the Kruskal-Wallis H Test

Inclusion criteria: The patients were diagnosed with coccydynia by history, clinical examination, lateral x-ray radiograph of coccyx (to exclude major fractures or dislocations that require surgery), gave their written consent and completed the pre- and post-treatment follow-up forms, were included in the study and their scores were statistically analyzed.

Exclusion criteria: Previous ESWT treatment, being under 18 years of age, sciatic pain, coagulation diseases, malignancies, infections, body implants and inability to cooperate have been determined as exclusion criteria. Patients over 65 years of age were not included in the study because of the concern that fragile and degenerative bone structure could be damaged with shock wave therapy.

Study design and randomization: The study was designed as a prospective, randomised, sham-controlled, and double-blind clinical trial with three parallel treatment groups (equal randomization 1:1:1). The treatment and follow-up process of the patients (those who applied directly to the sports medicine outpatient clinic or were referred from the physical therapy and orthopedics outpatient clinics) were completed between December 2021 and April 2022 at the Sports Medicine department of Van Yüzüncü Yıl University. Initially, a plan was devised to randomized more patients into 3 treatment groups (r-ESWT, f-ESWT and Sham ESWT). However, a mandatory change was made due to the curfews

related to the Covid-19 pandemic and the patients not applying to the hospital except for emergencies. Therefore, when the number of patients in each group reached to 20, the study was terminated. Figure 1 shows the flowchart of the participants and the randomization.

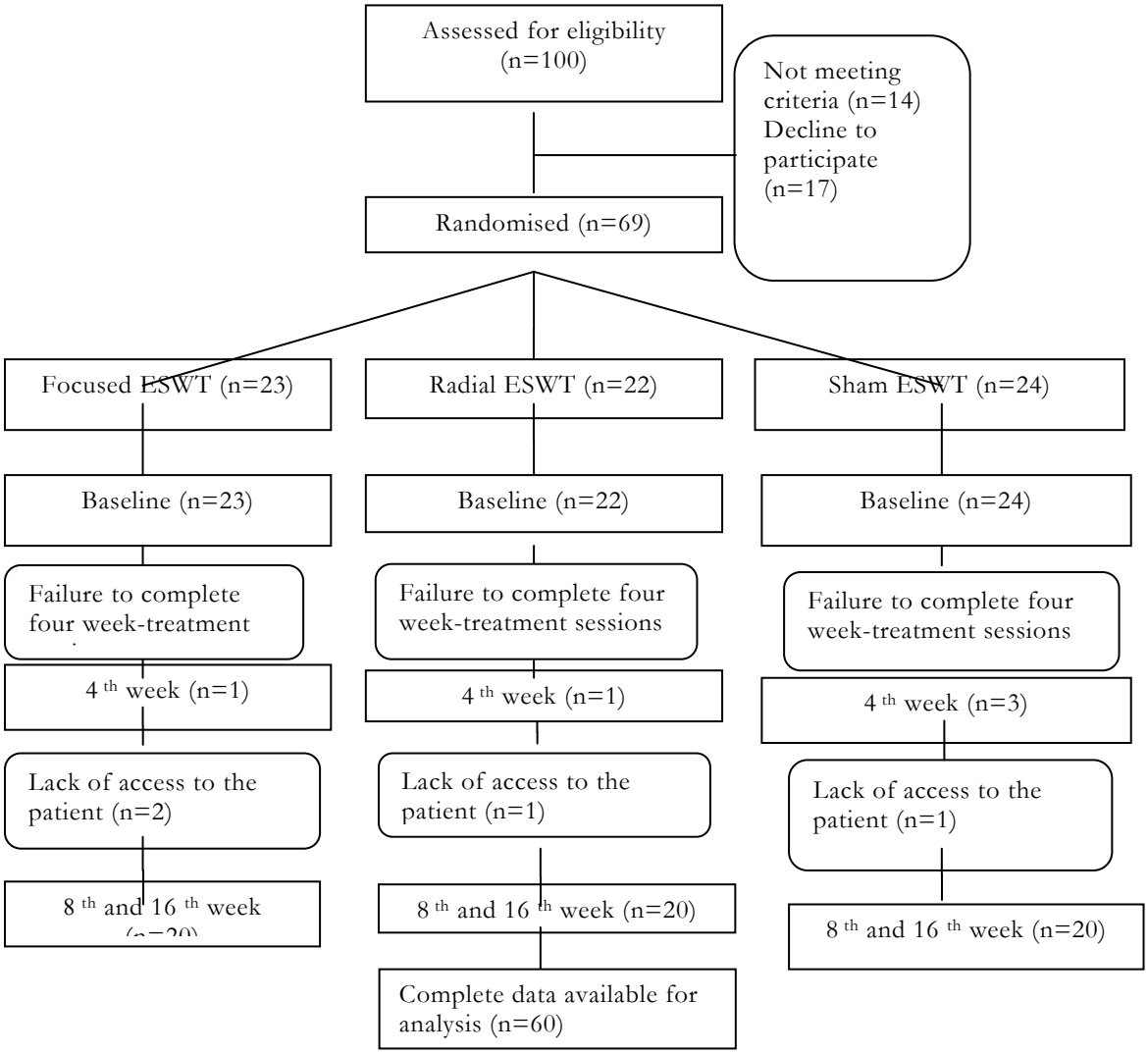

Figure 1. Flowchart of the study participants.

The randomization process was accomplished with blocked randomization All patients in both groups were given a single daily dose of 600 mg slow-release etodolac orally for first 10 days of the study. In addition, all group patients used a seat cushion until the study period was completed (16 weeks).

Sample size estimation: Since VAS was the primary variable in our study, the Sample Size (n) was calculated according to this parameter. According to the literature review, it was seen that the standard deviation for the VAS ranged between 0.9 and 1.3, and accordingly, the mean of the Standard Deviation was accepted as 1.1 in the calculation. In this context; Type 1 error was 5% (Z=1.96) and effect size was d=0.5 (based on the value range of the effect size conventions for the F test). Sample size (population size unknown) was calculated as $n=(1{,}96^2.1{,}1^2)/0{,}5^2=19$ according to the $n=(Z^2.\sigma^2)/d^2$ equation and it was planned that at least 20 patients in each group would be sufficient.

Blinding: The patients were not informed about the sequence of procedures and their differences from each other. A health personnel who was not involved in the study randomly assigned the participants to the treatment groups. The

treatments were applied by the physical therapy technicians who did not participate in patient distribution and blinded to the treatment follow-up records. The patients did not realize which treatment group they were included in, since ESWT had never been applied to the patients before, and similar pulse sounds were heard in all three groups of treatment. Researchers who did not participate in the collections evaluated the results. This allowed outcome evaluation to be blinded, which reduced the possibility of the study's detection bias.

Interventions: A total of 4 sessions of ESWT were applied to all group patients with the same device (Elettronica Pagani, Electro-pneumatic system, Italy) in the all sessions at 1-week intervals. The patients were asked to bring their hips and knees to maximum flexion while lying on their side, and the application was made to the coccyx region by means of a probe, using ultrasound gel and without local anesthesia. f-ESWT (8 Hz frequency, 1.8 Bar pressure, 1500 pulses shock waves, 0.02-0.60 mJ/mm^2 energy, 3 minutes 8 seconds duration per session) was applied to the first group, r-ESWT (8 Hz frequency, 1.6 Bar pressure, 1500 pulses shock waves, 0.02-0.60 mJ/mm^2 energy, 3 minutes 8 seconds duration per session) was applied to the second group, and Sham ESWT was applied to the third group. In Sham ESWT group, we used r-ESWT probe. Frequency (Hz), pressure (Bar) values and the time intervals were the same as in the r-ESWT. However unlike the r-ESWT, since this is a placebo application, the energy value was manually set to zero so that no therapeutic energy was transmitted to the patient.

Instruments and variables: VAS was used to measure the severity of pain felt by the patients at rest. There are levels on the scale from "no pain-0" to "worst possible pain-10". The Turkish validity and reliability study of the resting VAS was performed by Çetinkaya et al (19). ODI was used to evaluate functional status in low back pain. This questionnaire includes activities such as personal care, walking, sitting, sleeping, standing, lifting weights, social life and travel. The maximum score in the questionnaire is 100 points. An increase in score indicates an increase in functional limitation, while a decrease in score indicates an increase in functional level (20). Turkish validity and reliability study of the ODI was published by Yakut et al in 2004 (21). Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) scales have been recorded before the treatment (baseline), the day after the completion of 4 sessions of treatment (4th week), 1 month after the end of the treatment (8th week) and 3 months after the end of the treatment (16th week). Weight and height measurements were made by the secretary of the polyclinic with a device that measures both weight and height. Body mass index (BMI) was calculated as a person's weight in kilograms divided by the square of height in meters. VAS and ODI results were analyzed according to age groups (early adulthood 18-35, middle adulthood 36-50, older adulthood 51-65) and body mass index ranges (normal weight up to 24.9, overweight and obese for 25 and over).

Ethical approval statement: The study was conducted according to the principles of the Declaration of Helsinki. In this context, Yüzüncü Yıl University Clinical Research Ethics Committee approval was obtained (Decision No: 03; Date: December 12, 2021) and registered on 'Clinicaltrials.gov' with the number NCT05176431

Statistical analysis: The sample size of this study was calculated using the G*Power statistical program (ver.3.1.9.4). Type-1 error was considered as 5% and Power was calculated as 93% for 20 patients in each group, 60 patients in total. The continuous variables in the study were examined with the Shapiro-Wilk ($n<50$) test and nonparametric tests were applied because some of the measurements were not normally distributed and the number of samples for those with normal distribution was low. Descriptive statistics for continuous variables in the study expressed as "Mean, Standard Deviation, Median, Minimum and Maximum". The "Kruskal-Wallis H test" was used to compare the measurements between groups. "Friedman test" was used to compare the differences between the time periods of the measurements separately in the groups. Following the Kruskal-Wallis and Friedman tests, the "Post-Hoc Test with Bonferroni correction" was used to determine different groups and time periods. Pearson correlation coefficients were calculated to determine the relationships between continuous variables. Statistical significance level (a) was considered as 5% and SPSS (IBM SPSS for Windows, ver.26) statistical package program was used for all statistical analysis.

Results

The mean VAS changes according to the age ranges in the treatment groups are shown in Table 2. There was no statistical difference of VAS between the groups in terms of age ranges at the baseline ($p>0.05$). The mean VAS scores of thr r-ESWT group patients aged 18-35 showed a statistically significant decrease in the 4th, 8th and

16th weeks, while they decreased in the 8th and 16th weeks in the 36-50 age range ($p<0.05$). In the f-ESWT group, mean VAS scores were found to be significantly lower at the 8th and 16th weeks in both 18-35 and 36-50 age ranges ($p<0.05$). However, the mean VAS score reduction (5.25) in the 18-35 age range at 16 week was higher in the r-ESWT group than the same age patients in f-ESWT group (3.92). There were no significant time-dependent mean VAS score changes in 51-65 age range in the r-ESWT and f-ESWT groups. The mean VAS changes according to the BMI ranges in the treatment groups are shown in Table 3. There was no statistical difference of VAS between the groups in terms of BMI at the baseline. Mean VAS scores were found to be significantly lower at 8 and 16 weeks compared with baseline in both normal and overweight/obese patients in the r-ESWT and f-ESWT groups ($p<0.05$). The decrease in mean VAS scores (3.79) of normal weight patients in the r-ESWT group was greater than the decrease (3.45) in normal weight patients in the f-ESWT group at last check (16th week) compared with baseline. However, mean VAS score reduction (5.18) in overweight and obese patients in the f-ESWT group was greater than in patients with the same BMI range in the r-ESWT (2.83) at last check (16th week) compared with baseline. The mean ODI changes according to the age ranges in the treatment groups are shown in Table 4. There was no statistical difference of ODI between the groups in terms of age ranges at the baseline. Mean ODI scores in the 18-35 and 36-50 age ranges decreased statistically significantly at only16 weeks in both the r-ESWT and f-ESWT groups. However, the decrease in ODI scores of patients aged 18-35 in the r-ESWT group (38.3) was higher than that in the same age group of the f-ESWT group (25.0). On the other hand, the decrease in ODI scores of 36-50 years old patients in the f-ESWT group (26.1) was higher than the patients in the same age range (24.4) of the r-ESWT group. The mean ODI changes according to the BMI ranges in the treatment groups are shown in Table 5. There was no statistical difference of ODI between the groups in terms of BMI at the baseline. Statistically significant ODI score reduction was observed in all BMI indices in both r-ESWT and f-ESWT groups only at week 16 ($p<0.05$). However, the decrease in ODI scores of normal weight patients in the r-ESWT group (35.3) was greater than in the same BMI patients in the f-ESWT group (26.07). On the other hand, the decrease in ODI scores of overweight and obese patients in the f-ESWT group (47.7) was greater than in the same BMI patients in the r-ESWT group (17.65). Sham ESWT group did not show statistically significant mean VAS and ODI score reductions in any age range and in any BMI range at the control weeks. Both the f-ESWT and r-ESWT produced significantly superior VAS and ODI score improvements (for both $p<0.05$) over the Sham ESWT at all age and BMI ranges. No side effects were observed in any patient related to etodolac or ESWT administration.

Table 2: VAS changes in the ESWT wave groups according to the Age

Wave Type	Age (year)	n	Baseline VAS		4th week VAS		8th week VAS		16th week VAS		
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	*p.
Focused	18-35	11	8.00[a]	1.35	7.33[a]	1.37	4.92[b]	2.15	4.08[b]	2.07	0.001
	36-50	7	6.57[a]	1.99	7.14[a]	1.86	5.29[b]	1.70	4.14[b]	2.19	0.001
	51-65	2	9.12	2.25	9.00	2.29	7.18	2.76	7.01	2.85	0.098
Radial	18-35	8	8.00[a]	1.77	7.05[b]	1.49	4.25[c]	1.98	2.75[d]	1.98	0.001
	36-50	7	7.14[a]	1.95	5.86[a]	1.57	3.57[b]	1.13	3.29[b]	1.11	0.001
	51-65	5	8.00	1.87	7.00	2.24	5.20	0.84	3.20	2.17	0.065
Sham	18-35	12	6.42	1.93	5.00	2.00	5.27	1.95	5.18	2.48	0.073
	36-50	6	7.33	1.63	7.17	1.47	6.67	1.75	6.00	2.10	0.626
	51-65	2	6.50	0.71	7.00	1.41	6.00	0.00	5.50	0.71	0.392
	**p.		0.179		0.057		0.041		0.002		

VAS: Visual Analogue Scale; **ESWT:** Extracorporeal shock wave therapy
***** Significance levels according to Friedman Test; a,b,c: Shows the time difference (Bonferroni post-hoc test)
****** Significance levels according to the Kruskal-Wallis H Test (Shows the difference between the groups)
P-values with $p<0.05$ are shown in bold. **SD:** Standard Deviation

Table 3: VAS changes in the ESWT wave groups according to the BMI

Wave Type	BMI (kg/m²)	n	Baseline VAS		4th week VAS		8th week VAS		16th week VAS		*p.
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Focused	Normal (BMI <25)	9	7.78a	1.64	7.89a	1.45	5.67b	1.32	4.33b	1.56	0.001
	Overweight/Obese (BMI ≥25)	11	7.36a	1.80	6.91a	1.51	4.00b	1.46	2.18c	1.41	0.001
Radial	Normal (BMI <25)	3	8,00a	1.73	6.75b	0.54	5.57c	1.53	4.21d	1.62	0.048
	Overweight/Obese (BMI ≥25)	17	7.65a	1.87	6.80a	1.82	4.73b	2.33	4.82b	1.65	0.001
Sham	Normal (BMI <25)	6	7.33	1.86	5.00	1.41	5.00	2.19	4.67	2.80	0.079
	Overweight/Obese (BMI ≥25)	14	6.43	1.70	6.21	2.19	6.00	1.62	5.57	1.45	0.175
	**p.		0.179		0.057		0.041		0.002		

VAS: Visual Analogue Scale; **ESWT:** Extracorporeal shock wave therapy; **BMI:** Body Mass Index
***** Significance levels according to Friedman Test; a,b,c: Shows the time difference (Bonferroni post-hoc test)
****** Significance levels according to the Kruskal-Wallis H Test (Shows the difference between the groups)
P-values with p<0.05 are shown in bold. **SD:** Standard Deviation

Table 4: ODI changes in the ESWT wave groups according to the Age

Wave Type	Age (year)	Baseline ODI			4th week ODI		8th week ODI		16th week ODI		
		n	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*p.
Focused	18-35	11	58.50a	14.87	54.00a	15.40	45.67a	20.14	33.50b	17.71	0.001
	36-50	7	54.57a	16.92	53.71a	19.71	42.29a	16.43	28.43b	16.56	0.001
	51-65	2	76.04	17.52	77.12	18.98	62.00	18.45	60.23	18.20	0.097
Radial	18-35	8	60.00a	14.62	59.50a	16.34	45.75a	19.58	21.75b	11.42	0.001
	36-50	7	52.00a	21.66	46.00a	16.57	38.00a	8.93	27.57b	9.50	0.003
	51-65	5	61.60	19.92	60.80	18.58	43.20	8.79	20.80	15.27	0.150
Plasebo	18-35	12	42.83	21.75	39.17	18.87	36.33	14.19	33.67	15.16	0.301
	36-50	6	59.67	19.61	60.00	20.71	56.33	19.65	50.33	23.30	0.525
	51-65	2	55.00	1.41	59.00	12.73	49.00	1.41	45.00	7.07	0.290
	**p.		0.356		0.463		0.326		0.003		

ODI: Oswestry Disability Index **ESWT:** Extracorporeal shock wave therapy
***** Significance levels according to Friedman Test; a,b,c: Shows the time difference (Bonferroni post-hoc test)
****** Significance levels according to the Kruskal-Wallis H Test (Shows the difference between the groups)
P-values with p<0.05 are shown in bold. **SD:** Standard Deviation

Table 5: ODI changes in the ESWT wave groups according to the BMI

Wave Type	BMI (kg/m²)		Baseline ODI		4th week ODI		8th week ODI		16th week ODI		
		n	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*p.
Focused	Normal (BMI <25)	9	58.67a	15.30	56.00a	15.20	49.33a	13.57	32.67b	17.59	0.001
	Overweight/Obese (BMI ≥25)	11	57.64a	16.61	54.55a	19.31	43.45a	14.03	20.00b	9.26	0.001
Radial	Normal (BMI <25)	3	65.33a	16.65	63.33a	4.16	51.23a	10.24	30.00b	11.00	0.040
	Overweight/Obese (BMI ≥25)	17	56.24a	18.51	53.65a	18.58	49.53a	19.85	38.59b	12.61	0.001
Sham	Normal (BMI <25)	6	49.33	23.28	44.33	21.03	40.67	17.42	34.00	21.24	0.444
	Overweight/Obese (BMI ≥25)	14	49.00	20.81	48.71	21.42	44.86	18.02	42.29	17.36	0.079
	**p.		0.356		0.463		0.326		0.003		

***** Significance levels according to Friedman Test; a,b,c: Shows the time difference (Bonferroni post-hoc test)
****** Significance levels according to the Kruskal-Wallis H Test (Shows the difference between the groups)
P-values with p<0.05 are shown in bold. **SD:** Standard Deviation
ODI: Oswestry Disability Index **ESWT:** Extracorporeal shock wave therapy **BMI:** Body Mass Index

Discussion

The exact mechanisms about pain-relieving effect of ESWT has not been clearly elucidated, some hypotheses have been put forward. It has been suggested that inflammatory changes are observed in the coccygeal region in patients with coccydynia (2) and ESWT has an anti-inflammatory effect by reducing inflammatory cytokines such as interleukins and matrix metalloproteinases (22). ESWT has been shown to improve tissue healing by increasing TGFβ1 and IGF-1 expression. ESWT may also have a neovascularization-inducing effect by increasing the expression of vascular endothelial growth factor, endothelial nitric oxide synthase and proliferating cell nuclear antigen (23). Although there are publications on the efficacy of ESWT in the treatment of coccydynia, (15–18,24), any study comparing the effectiveness of ESWT wave types in the treatment of coccydynia according to age or/and body mass index could not be found in the literature. These previous studies about the treatment of coccydynia with ESWT (15–18,24), have shown that ESWT was effective according to both pain and physical function scores in the treatment of coccydynia. It was noted that their device frequencies were between 5 Hz and 21 Hz, pressures between 2 and 4 bar, wave pulses were 2000 or 3000 and energy flux was set as 0.2 mJ/mm2. In our study, the frequency value assigned by the device in both wave types (8 hz) was similar to those in these studies, while the pressure values were 1.8 bar in Focused Wave and 1.6 bar in Radial Wave in the device we used. The slightly lower pressure and wave pulses (1500 shockwaves) in our study may be due to the fact that we used a device (Electro-pneumatic featured) that produces higher energy values (up to 0.6 mJ/mm² automatically) by requiring less pressure. It was seen that f-ESWT was used in some studies (15,16,24) and the r-ESWT was used in others (17,18). However it was not specified which ESWT wave type was chosen on what basis in these studies. In addition, an evaluation according to the age and body mass index of the patients was not included in these studies. In this study; both the r-ESWT and f-ESWT were found to be effective in coccydynia patients aged between 18-50 years and in all the BMI ranges (normal, overweight/obese) according to the VAS and ODI scores. However, there was no statistically significant benefit in all three ESWT groups in the 51-65 age range according to the VAS and ODI scores. Since the r-ESWT reduces VAS and ODI scores at the 16th week of patients aged 18-35 more than the f-ESWT patients in the same age range, Radial ESWT seems to be more effective in younger (18-35) patients with coccydynia. The r-ESWT might be the first choice in normal weight coccydynia patients because it has reduced VAS scores at 8th and 16th weeks and ODI scores at 16th week more than the f-ESWT patients in normal BMI range. These inferences may be related to the better reaching of the radial ESWT waves to the surrounding ligaments and muscles that can be a source of pain in the horizontal plane of the coccyx (25). The VAS score reduction of overweight/obese patients in the f-ESWT group was greater than that of patients with the same body mass index in the r-ESWT group at weeks 8 and 16. The 16th week ODI scores in the 36-50 age range were lower in the f-ESWT group than in the r-ESWT group in the same age range. ODI scores in overweight/obese patients in the f-ESWT group were also lower at week 16 than patients in the

same body mass index in the r-ESWT group. Based on these, we had statistical evidence to say that, f-ESWT is more effective in the age range of 36-50 years and/or in overweight/obese patients.
The decrease in subcutaneous adipose tissue with increasing age suggests that r-ESWT may be more effective in older ages, but it should not be forgotten that fibrous tissue replaces adipose tissue at these ages (12). It seems possible to overcome the fibrous tissue, which is a harder tissue than the adipose tissue, with the f-ESWT application. Thef-ESWT might be preferable in overweight/obese and 36-50 aged patients. This inference may be related to the fact that f-ESWT waves, which can reach deeper tissues, pass through thicker subcutaneous fat tissues better in overweight/obese patients or through thicker subcutaneous fibrous tissues better in older patients (26,27). The ineffectiveness of both the f-ESWT and r-ESWT in terms of VAS and ODI scores in the 51-65 age group may be related with the small number of patients in this age range in our study. It also may be caused by additional degenerative process in coccyx and and changes in the perception of pain, with aging (28,29). There is also pain and inflammation in the surrounding ligaments and muscles in coccydynia in addition to the pain of the coccyx itself (25). In patients with normal weight and younger ages, since the subcutaneous layers that ESWT waves have to cross in order to reach the coccyx are thinner than in overweight/obese patients and softer than older aged patients. So, it should be aimed to spread the waves to the ligaments and muscles around the coccyx rather than than deep impact to a focused point. The r-ESWT which is suitable for this purpose (26,27) can be preferred in normal weight and in 18-35 aged patients. Since there is a thicker subcutaneous fat tissue or more solid subcutaneous fibrous tissue for ESWT waves to reach the coccyx in overweight/obese or 36-50 aged patients (13), the primary goal should be to pass these layers. The f-ESWT might be preferable in overweight/obese and/or middle adulthood patients for this purpose.
Study limitations: Our study has some limitations. The cause of coccidynia in each patient was not investigated. X-ray radiograph was taken only to distinguish the conditions requiring surgical intervention. Whether there was coccyx angulation or not, if so, directions and degrees were not recorded. Advanced imaging techniques such as CT or MRI were not used. This was a pilot study on this subject, similar studies can be conducted with larger patient series and longer follow-up periods. Future studies may include only one gender, thus creating more homogeneous treatment groups.

Conclusion

According to the results of our study, both the r-ESWT and f-ESWT were found to be effective in patients in coccydynia with 18-50 aged patients. It may be more appropriate to prefer other treatment modalities than ESWT at older ages (>50). While the r-ESWT should be considered as the first choice in young (18-35) and normal weight coccydynia patients, the f-ESWT should be given priority in relatively older (35-50) and overweight/obese patients with coccydynia.

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