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*RESEARCH ARTICLE*

# INTERFERENTIAL CURRENT, ULTRAHIGH-FREQUENCY CURRENT, AND EXERCISES FOR RECURRENT KNEE PAIN DUE TO OSTEOARTHRITIS

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Knee Joint, Osteoarthritis, Interferential Current, Ultrahigh-Frequency Current, Exercises

## *Abstract*

**Introduction:-** There are no studies in the literature on the combined effect of interference current, ultrahigh-frequency current, and exercise in recurrent knee pain due to osteoarthritis. There is no consensus on the optimal frequency, duration, and intensity of exercise.
**Aim:-** To study the effect of interferential current, ultrahigh-frequency current, and exercises in recurrent knee pain due to osteoarthritis and to discover the optimal frequency, intensity, and duration of exercises.
**Material and Methods:-** Twelve outpatients (age 63.43±6.24 years) with recurrent knee pain due to osteoarthritis (average pain duration 6.71±5.21 years and last recurrence 3.92±1.56 before study enrolment) were followed-up for one month. They were treated for the first two weeks with interferential current, ultrahigh-frequency current, and exercises. All outpatients were instructed to perform the exercises as often as possible, as long as possible, and as intense as possible at home for one month. The pain was measured by a visual analogue scale daily for the two-week course and after one month. In the beginning, in the middle, and at the end of the month were recorded the mobility in the knee joints by goniometry, the strength of the periarticular muscles by manual muscle testing, WOMAC parameters, frequency, intensity, and duration of the exercises.
**Results:-** During the two-week course, the pain was decreasing every following day ($P>0.05$). Over the weekend the pain increased ($P<0.05$). After two weeks and after one month the pain ($P<0.05$), mobility ($P>0.05$), muscle strength ($P>0.05$), and WOMAC parameters ($P>0.05$) significantly improved. There was a significant correlation and regression between pain and exercise frequency ($P<0.05$). With an exercise frequency greater than five times daily, the pain regressed to zero ($P<0.05$). There was no correlation between pain and exercise intensity ($P>0.05$) and between pain and exercise duration ($P>0.05$).
**Discussion:-** The improvement of the pain during the week and its worsening during the weekend showed that interferential current and ultrahigh-frequency current had a short-term analgesic effect. The improvement of all parameters after one month showed that exercises had a long-term effect. The presence of a correlation and regression between pain and exercise frequency, combined with a lack of correlation between pain and exercise intensity or duration, indicated that frequent, short, and low-intensity exercises were optimal.

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**Conclusion:-** The combination between interferential current, ultrahigh-frequency current, and exercise is effective in recurrent knee pain due to osteoarthritis. Short and low-intensity exercises with a frequency of more than five times a day are optimal.



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## Introduction:-

Osteoarthritis of the knee is one of the most common causes of pain and disability [1-7]. Half of all people over the age of 65 have osteoarthritic changes in the knee joints [2-7].

Often osteoarthritis of the knee is treated with exercise and physical factors [1,2,7-12]. Exercise has both short-term and long-term symptomatic (analgesic) effects and pathogenetic effects on muscle balance, joint stability, and mobility [1,13-19]. Strength exercises for elongated and flabby dynamic muscles correct the muscle imbalance and increase joint stability [1,13-15,17,18,20]. Relaxing exercises for shortened and spastic static muscles correct the muscle imbalance and increase joint mobility [1,21,22]. There is a consensus on the therapeutic effect of the exercises, but their optimal frequency, duration, and intensity are not known [1].

Interference current has a short-term electro analgesic effect in osteoarthritis of the knee [1,8,23-32]. Several electro analgesic theories have been proposed: central-level gate theory [1,33,34], peripheral-level beta-endorphins release theory [1,9,11,35], receptor-level hyperpolarisation theory [1,9,11] and microcirculatory-level metabolic theory [1,9,11].

Ultra-high frequency current has a short-term analgesic effect in osteoarthritis of the knee due to its endogenous thermal effect, which does not burden the thermoregulation, respiratory and cardiovascular systems [1,9,11,36]. The reason is that the skin is not a barrier to ultra-high frequency current [1,9,11,36]. Endogenous heat is formed indirectly in depth by the transformation of electromagnetic external energy into kinetic energy of dipole molecules [1,9,11,36]. This causes the tissues to heat up from their high-frequency oscillations, trying to direct their positive and negative poles to the high-frequency change of polarity [1,9,11,36]. In addition, endogenous heat from ultra-high frequency current is selective - it can heat tissues with high or low water content, depending on the type of electrodes [1,9,11,36].

There are no studies in the literature on the combined effect of interference current, ultra-high frequency current, and exercise in recurrent knee pain due to osteoarthritis. There is no consensus on the optimal frequency, duration, and intensity of exercise.

The aim was to study the effectiveness of the combination of interference current, ultra-high frequency current, and exercise in the rehabilitation of recurrent knee pain due to osteoarthritis and to find the optimal frequency, intensity, and duration of exercise.

## Material and Methods:-

Twelve outpatients (age 63.43 ± 6.24 years) with recurrent knee pain due to osteoarthritis (mean pain duration 6.71 ± 5.21 years and last recurrence 3.92 ± 1.56 weeks before study enrolment) were followed for one month. They were treated for the first two weeks with interference current, ultra-high frequency current, and exercise.

The interference current was applied by a four-electrode stable method. The electrodes were placed transversely above and below the knee so that the electromagnetic fields of the two current circuits interfere in the painful area. Rhythmic change of frequencies 90-100 Hz was used, without vector with a duration of the procedure 10 min. [1,8,23-32].

The ultra-high frequency current was applied with capacitor electrodes, located transversely at a distance of 3 cm from the knee surface. The duration of the procedure was 10 minutes with a constant mode [1,9,11,12,19,20].

The exercises were performed under the supervision of a rehabilitator once a day for 10 minutes. The shortened and hypertonic static muscles (m.rectus femoris, m.biceps femoris, m.semitendinosus, m.semimembranosus, and m.gastrocnemius) were treated by relaxation exercises - with post isometric relaxation [37] and stretch [22]. The elongated and flabby dynamic muscles (m.vastus medialis, lateralis, and intermedius) were treated by strengthening exercises [38]. All outpatients were instructed to perform these exercises as often as possible, as long as possible, and as intensively as possible at home for one month.

The pain was reported by a visual analogue scale daily for two weeks and after one month [1,39]. In the beginning, in the middle, and at the end of the month, the mobility in the knee joints, the strength of the surrounding muscles, WOMAC parameters [21, 23], frequency, intensity, and duration of exercise were registered. The mobility in the knee joints was measured with goniometry [1,40]. To calculate total knee mobility in percentages, angular degrees were transformed into percentages of normal mobility - the sum of the percentages in knee flexion and extension was divided by two. The strength of the surrounding muscles was measured with manual muscle testing [1,40]. To calculate the total strength of the surrounding muscles in percentages, the degrees of manual muscle testing were transformed into percentages of normal strength - the sum of the percentages of the flexors and extensors of the knee joint was divided by two.

For statistical processing of the results, analysis of variances (ANOVA) with a multiple post-hoc Bonferroni test and Pearson correlation analysis with post-hoc multiple regressions analyzes were used.

## Results:-

During the two-week course, the pain was decreasing every following day (P<0.05). Over the weekend, the pain increased (P<0.05). After two weeks and after one month, the pain significantly decreased (P<0.05) (**Figure 1**).

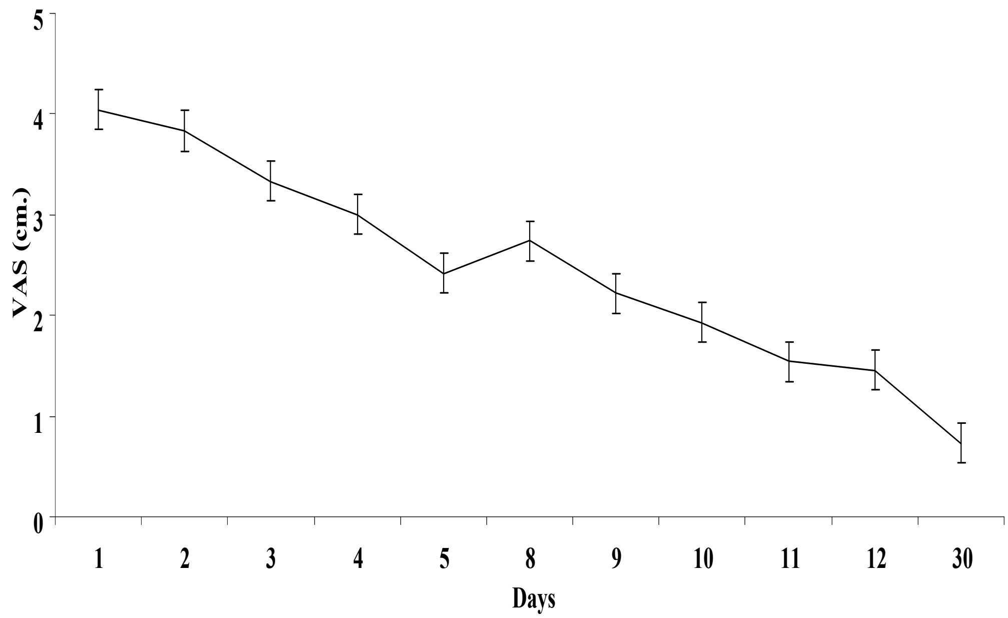


**Figure 1:-** Pain intensity reported by a visual analogue scale (VAS in cm.) daily for two weeks and after one month. The sixth and seventh days are a weekend.

The mobility in the knee joint and the strength of the periarticular muscles increased at the end of the two-week therapeutic course compared to the beginning (P<0.05) and after one month compared to the end of the two-week therapeutic course (P<0.05).

There was no correlation between pain and age (P>0.05), between pain and exercise intensity (P>0.05), and between pain and exercise duration (P>0.05). There was a significant correlation and regression between pain and muscle strength (P<0.05), between pain and joint mobility (P<0.05), and between joint mobility and muscle strength (P<0.05). The three-dimensional multiple regression relationship between pain, joint mobility, and muscle strength (P<0.05) is presented in **Figure 2**.

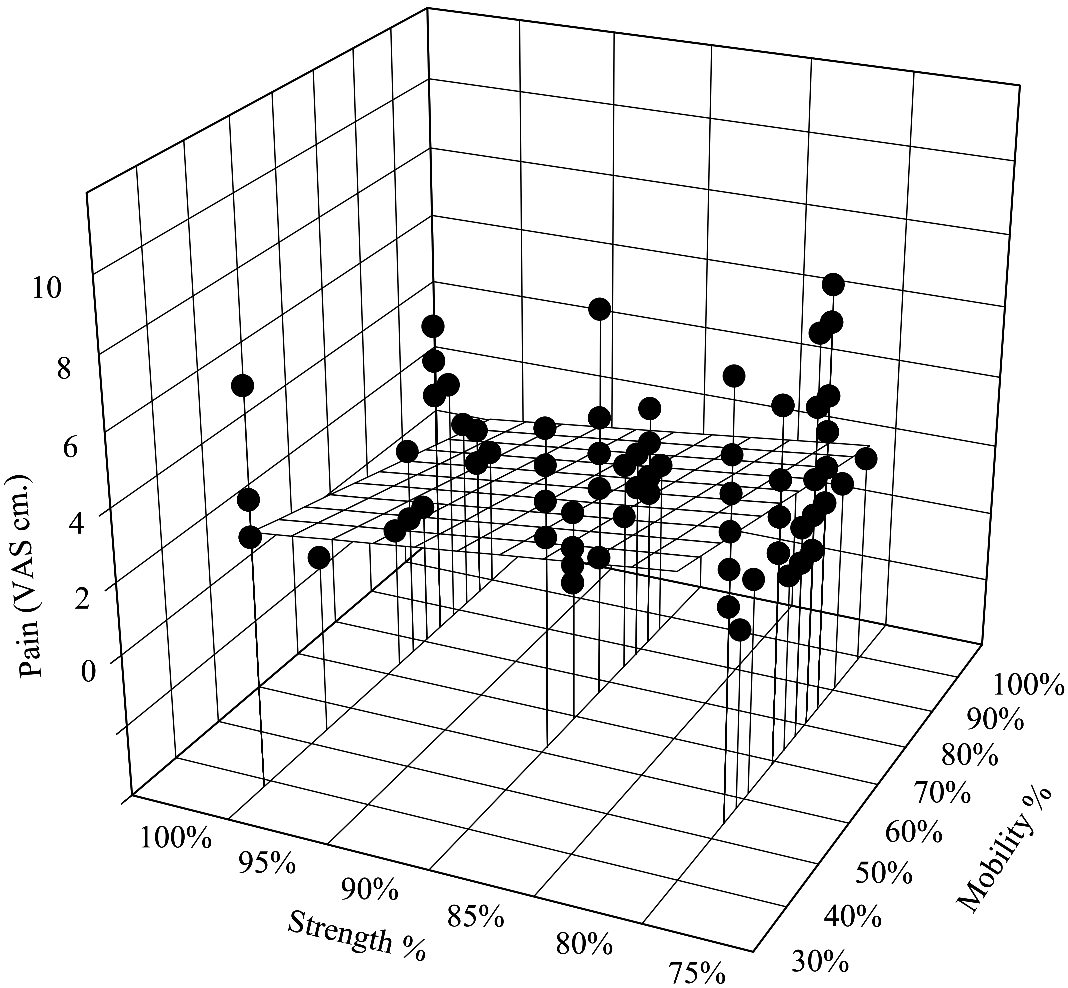


**Figure 2:-** Three-dimensional regression between pain (VAS in cm.), joint mobility (in % of the norm), and joint muscle strength (in % of the norm).

Correlation analysis found an inverse proportional relationship between pain and exercise frequency ($P<0.05$). Regression analysis found that the intensity of pain was decreasing significantly with increasing frequency of exercise ($P<0.05$) according to the following formula:

VAS (cm.) = 3.64 - (0.721 * daily exercise frequency) (Figure 3):

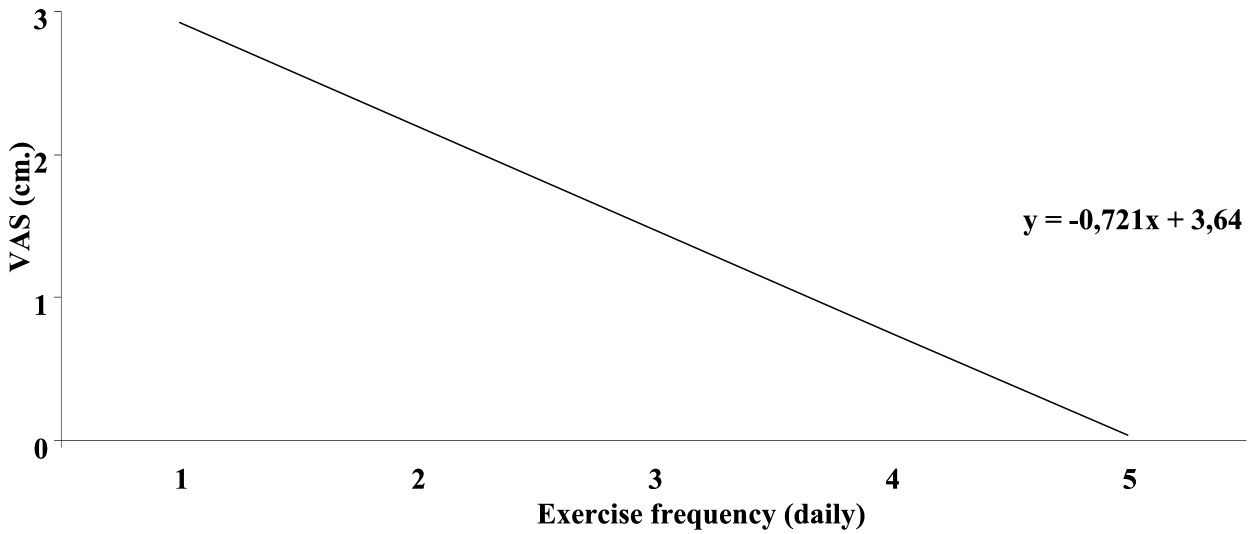


**Figure 3:-** Regression analysis between pain (VAS in cm.) and daily exercise frequency.

According to this formula (y=-0.721x+3.64), at an exercise frequency of more than five times a day the pain showed a regressive tendency to decrease to zero ($P<0.05$), while at an exercise frequency of less than once a day, the pain showed a progressive tendency to increase over 3 cm. (VAS in cm.) ($P<0.05$) (Figure 3).

## Discussion:-

The results support the opinion that interference and ultra-high frequency current have a short-term symptomatic effect [2-9,11,12,23,27,36,41,42] because, after two weeks of physiotherapy, the knee pain decreased. In addition, our results showed that pain decreased significantly not only after a two-week course but also after every following day of physiotherapy. In addition, the increase in pain over the weekend proved the presence of a short-term symptomatic effect of the interference current and ultra-high frequency current, as their cessation in two days led to a return of pain.

The results support the opinion that exercise has short-term and long-term symptomatic and pathogenetic effects [13-19] because, after two weeks of physiotherapy with exercises and additional two weeks of exercises only, knee pain decreased, joint mobility increased, muscle strength increased, and WOMAC parameters improved. It was found that only the frequency of exercise had a significant therapeutic effect, as only it correlated with pain, while the intensity and duration of exercise did not correlate with the pain. Regression analysis found that with an exercise frequency of more than five times a day, the pain was close to zero. Therefore, short-term and low-intensity exercises with a frequency of more than five times a day are optimal. Increasing the intensity and duration of exercise does not reduce pain, but may increase the risk of injury.

The lack of a significant correlation between pain and age, combined with increasing degenerative changes with age, suppose that there is no relationship between the degree of degenerative changes and the degree of pain. With significant degenerative changes, the pain may have a lower intensity compared to minor image changes and vice versa - with minor degenerative changes, the pain may have a higher intensity compared to significant image changes. The significant correlation between pain and joint mobility suppose that pain causes muscle guard with shortening and hypertonicity of static muscles that restrict mobility, and vice versa - limited mobility leads to their shortening and increase in pain. The significant correlation between pain and muscle strength suppose that pain inhibits the strength of dynamic muscles, leading to their hypotrophy or atrophy, and vice versa - reduced strength leads to joint instability and pain. Electroanalgesia with interference and high-frequency current contributes to the short-term cessation of the vicious cycle (pain-hypomobility-instability-imbalance) during recurrences. Deepening muscle imbalance with flabbiness and atrophy of dynamic muscles and shortening with hypertonicity of static muscles leads to increased pain, joint instability, and hypomobility. All this shows that therapeutic and prophylactic exercises are needed, aimed at correcting muscle imbalance, increasing joint stability, and mobility.

## Conclusion:-

The combination of interference current, ultra-high frequency current, and exercise is effective in recurrent knee pain due to osteoarthritis. Short and low-intensity exercises with a frequency of more than five times a day are optimal.

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