Study of the efficacy of hydrotherapy, electromagnetic waves and therapeutic exercises to treat low back pain: Using nonparametric tests

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الخلاصة

يهدف البحث إلى التعرف على تأثير برنامج مقترح باستخدام العلاج المائي والموجات الكهرومغناطيسية والتمارين العلاجية لعلاج آلام أسفل الظهر ، على قوة العضلات ، ومدى الحركة ، ودرجة الألم للمجموعة التجريبية (الحاراتي و البدري ، 2022)، باستخدام طرق غير معلمية اختبار ويلكوكسون واختبارات مان ويتني. تم اختيار اثني عشر فردًا بطريقة غير عشوائية من الحالات التي تعاني من آلام أسفل الظهر ، والذين التحقوا بقسم العلاج الطبيعي بالمستشفى الجامعي التعليمي (مركز طرابلس الطبي)، والذين تراوحت أعمارهم بين (30 – 35) عامًا للذكور. تم تقسيم شدة الألم في مجموعات ضابطة وتجريبية الي قياسات قبلية وبعدية. نستنتج انه توجد فروق ذات دلالة إحصائية بين القياسين القبلي والبعدي للمجموعتين الضابطة والتجريبية لصالح القياس البعدي في جميع متغيرات الدراسة (المدى الحركي، القوة العضلية ودرجة الألم)، وكذلك وجود فروق ذات دلالة إحصائية بين المجموعتين التجريبية و الضابطة ولصالح المجموعة التجريبية في جميع متغيرات الدراسة (المدى الحركي، القوة العضلية، درجة الألم).

الكلمات الدالة: العلاج المائي، الموجات الكهرومغناطيسية، التمرينات العلاجية، اختبار ويلكوكسون، واختبار مان ويتني.

Abstract

The research aims to identify the effect of a proposed program using hydrotherapy, electromagnetic waves and therapeutic exercises to treat lower back pain, on muscle strength, range of motion, and degree of pain for the experimental group (see El-Harari and Elbadri, 2022), using nonparametric methods such as Wilcoxon signed-rank, and Mann-Whitney U tests. Twelfth individuals were selected in nonrandom way from cases suffering from lower back pain, who attended the Physiotherapy Department at the University Teaching Hospital (Tripoli Medical Center), and whose ages ranged between (30 - 35) years of males. The intensity of pain was divided into control and experimental groups with pre and post measurements. There were significant differences between the pre and post measurements of the control and experimental groups in favor of the post measurement in all study variables (motor range, muscular strength and pain degree), as well as, the presence of significant differences between the experimental and control group and in favor of the experimental group in all study variables (motor range, muscular strength and pain degree).

Key words: Hydrotherapy, Electromagnetic waves, Therapeutic exercises, Wilcoxon signed-rank, and Mann-Whitney U tests.

1. Introduction

Low back pain is one of the most common disorders affecting the musculoskeletal system, and it is considered the most prevalent today modern, it still constitutes a real health challenge in terms of prevention and treatment, and these pains occupy the third after coronary heart disease and cancer (see, Jalaluddin and Bakri, 2011, Serdah and Abu Obeid, 2013, Bin Imran, 2004, Mahmoud and Ibrahim, 2014, Rashid, 2011 and Al-Sarraj, 2010). This paper identify the effect of a proposed program using hydrotherapy, electromagnetic waves and therapeutic exercises to treat lower back pain, on muscle strength, range of motion, and degree of pain for the experimental group (see El-Harari and Elbadri, 2022). Statistical analysis was performed using nonparametric methods such as Wilcoxon signed-rank, and Mann-Whitney U tests.

2. Methods

Statistical analysis was performed using SPSS. Nonparametric tests (Wilcoxon signed-rank and Mann-Whitney U tests) were used to determine whether differences existed among the exercises and control groups over five measurement for back pain. A Wilcoxon signed-ranks test as a post hoc test was applied to assess differences in the group. However, the Mann-Whitney U tests were then used to examine differences between groups. Statistical significance was set at $p < 0.05$.

2.1. Comparison of two related samples: Wilcoxon Signed Ranks test (see, Wilcoxon, 1945; Siegel, 1956)

This test is a nonparametric method of a paired t test. This test compares the pre- and post-treatment scores. For two related samples from a continuous field, record: the difference $d_i = X_{i1} - X_{i2}$ is computed, as well as the absolute value. All nonzero absolute differences are sorted into ascending order, and ranks are assigned. In the case of ties, the average rank is used. Let $D = \{d_i : |d_i| \neq 0\}$, then the sums of the ranks corresponding to positive and negative differences are

$$S_p = \sum_{i \in D} R_i(|d_i|; (d_i) > 0) \quad (1)$$

And

$$S_n = \sum_{i \in D} R_i(|d_i|; (d_i) < 0) \quad (2)$$

respectively. Then the average positive rank and average negative rank are

$$\bar{X}_p = \frac{S_p}{n_p} \quad (3)$$

And

$$\bar{X}_n = \frac{S_n}{n_n} \quad (4)$$

where n_p is the number of records with positive differences and n_n the number with negative differences. The test statistic is

$$T = \frac{S_p - \mu_T}{\sigma_T} \quad (5)$$

Where

$$\mu_T = \frac{n(n+1)}{4} \quad (6)$$

$$\sigma_T^2 = n(n+1)(2n+1)/24 - \sum_{j=1}^{l} \left(t_j^3 - t_j\right)/48 \quad (7)$$

$$n = \sum_{i \in D} R_i \quad (8)$$

where l is the total number of distinct rank values and t_j is the number of records tied at the jth distinct value, incorporating the frequency weight. The one-sided and two-sided p-values are

$$p = P_r(Z \geq |T|) = 1 - \emptyset(|T|) \quad (10)$$

$p < \alpha$ will reject the null hypothesis in favor of $\theta > 0$ if $T > 0$ and $\theta < 0$ if $T < 0$.

2.2. Comparison of two independent samples: Mann-Whitney U test (See, Mann and Whitney, 1947)

The Mann-Whitney U test is used to compare differences between two independent groups. The data from both samples are sorted and ranks, with average rank being used in the case of ties. The sum of the ranks is calculated for both samples (S_1 and S_2), as well as, for tied observations, $T_i = \frac{t^3 - t}{12}$, where t is the number of observations tied for sample i. The average rank for sample i is

$$\bar{S}_i = \frac{S_i}{m_i} \quad (11)$$

where m_i is the sample size in sample i. The Mann-Whitney U statistics are
defined by the following, for sample 1

$$\mathrm{U} = \mathrm{m_1 m_2} + \frac{\mathrm{m_1(m_1+1)}}{2} - \mathrm{S_1} \quad (12)$$

If $U > m_1 m_2/2$, the statistic is

$$U' = m_1 m_2 - U \quad (13)$$

If $m_1 m_2 \leq 400$ and $m_1 m_2/2 + min(m_1, m_2) \leq 220$ the exact significance level is based on an algorithm of Dineen and Blakesley (1973). A normal approximation, as shown by Mann and Whitney (1947), can be used. So, the test statistic corrected for ties is

$$Z = \frac{(U - m_1 m_2/2)}{\sqrt{\frac{m_1 m_2}{M(M-1)}\left(\frac{M^3 - M}{12} - \sum_i T_i\right)}} \quad (14)$$

where $M = m_1 + m_2$.

3. Data

Twelfth individuals were selected in nonrandom way from cases suffering from lower back pain resulting from muscle tension of the lower dorsal muscles, who attended the Physiotherapy Department

at the University Teaching Hospital (Tripoli Medical Center), and whose ages ranged between (30 - 35) years of males. The patients were divided into two groups, one of them was experimental from size 6 individuals used hydrotherapy, electromagnetic waves and therapeutic exercises and the other control of size 6 individuals used infrared therapy, ultrasound, electrical therapy and stretching exercises (see El-Harari and Elbadri, 2022).

4. Result

First, demographic data were compared between the exercises and control groups for age, height, weight and body mass index (see, table 1). Each pre-measure of groups was analyzed by Mann Whitney test which demonstrated no significant differences between the groups with 5%.

Table 1: Comparison of baseline characteristics between patients in exercises and control groups for age, height, weight and body mass index

Demographics	Exercises group (n = 6)	Control group (n = 6)	$p-value$
Age, mean (SD)	33.50(1.871)	33.00(2.121)	0.707
Height, mean, cm (SD)	1.782(0.061)	1.746(0.068)	0.407
Weight, mean, kg (SD)	79.00(9.077)	79.80(7.190)	0.927
Body mass index, mean, kg/m2 (SD)	24.97(3.047)	26.29(3.422)	0.715

Secondly, each measurement for back pain of the control group was analyzed by Wilcoxon signed ranks test which demonstrated significant differences between the pre and post measurements for patients. For the flexing variable($p-value=0.039$), and for the extension variable, it is also (0.039), for a variable degree of pain (0.034) and the muscle strength (0.025) and the Swestry test variable (0.042). All of these values are statistically significant because they are less than 0.05, which indicates the presence of differences between the pre and post measurements in these variables, and this significance was in favor of the post measurement (see, table 2).

Table 2: Wilcoxon signed ranks test between the pre and post measurements for patients of the control group

Measurement for back pain		N	Sum of Ranks	Mean Rank	Z	P-value
The flexing	Negative Ranks	0	0.000	0.00	-2.060	0.039
	Positive Ranks	5	15.00	3.00		
	Ties	0				
The extension	Negative Ranks	0	0.000	0.00	-2.060	0.039
	Positive Ranks	5	15.00	3.00		
	Ties	0				
The degree of pain	Negative Ranks	5	15.00	3.00	-2.121	0.034
	Positive Ranks	0	0.000	0.00		
	Ties	0				
Muscle strength	Negative Ranks	0	0.000	0.00	-2.236	0.025
	Positive Ranks	5	15.00	3.00		
	Ties	0				
Swestry Test	Negative Ranks	0	0.000	0.00	-2.032	0.042
	Positive Ranks	5	15.00	3.00		
	Ties	0				

To verify the hypothesis of significant differences between the pre- and post-measurement of the experimental group in favor of the post-measurement, each measurement for back pain of the experimental group was analyzed by Wilcoxon signed ranks test which demonstrated significant differences between the pre and post measurements for patients. For the flexing variable($p - value = 0.027$), and for the extension variable, it is also (0.027), for a variable degree of pain (0.023) and the muscle strength (0.024) and the Swestry test variable (0.027). All of these values are statistically significant because they are less than 0.05, which indicates the presence of differences between the pre and post measurements in these variables, and this significance was in favor of the post measurement (see, table 3).

Table 3: Wilcoxon signed ranks test between the pre and post measurements for patients of the exercises group.

Measurement for back pain		N	Sum of Ranks	Mean Rank	Z	P-value
The flexing	Negative Ranks	0	0.000	0.00	-2.207	0.027
	Positive Ranks	6	21.00	3.50		
	Ties	0				
The extension	Negative Ranks	0	0.000	0.00	-2.207	0.027
	Positive Ranks	6	21.00	3.50		
	Ties	0				
The degree of pain	Negative Ranks	6	21.00	3.50	-2.271	0.023
	Positive Ranks	0	0.000	0.00		
	Ties	0				
Muscle strength	Negative Ranks	0	0.000	0.00	-2.264	0.024
	Positive Ranks	6	21.00	3.50		
	Ties	0				
Swestry Test	Negative Ranks	0	0.000	0.00	-2.207	0.027
	Positive Ranks	6	21.00	3.50		
	Ties	0				

Finally, table 4 shows the results of the Mann Whitney test between the two groups for the study variables in the post measurement. It appears that the significance level values for the flexing variable (0.004) and for the extension variable (0.003) and for the variable of the degree of pain was (0.003) and for the variable of muscle strength (0.003) and for the variable Swestry test (0.004). All these values are statistically significant because they are less than 0.05, which indicates that there are differences between the two groups in these variables in the post measurement, and the significance was in favor of the experimental group.

Table 4: Mann-Whitney U test between patients of the exercises and control groups in the post measurement

Measurement for back pain		N	Sum of Ranks	Mean Rank	Z	P-value
The flexing	Exercises Group	6	21.00	3.50	-2.908	0.004
	Control Group	6	57.00	9.50		
The extension	Exercises Group	6	21.00	3.50	-2.929	0.003
	Control Group	6	57.00	9.50		
The degree of pain	Exercises Group	6	57.00	9.50	-2.934	0.003
	Control Group	6	21.00	3.50		
Muscle strength	Exercises Group	6	21.00	3.50	-2.966	0.003
	Control Group	6	57.00	9.50		
Swestry Test	Exercises Group	6	21.00	3.50	-2.887	0.004
	Control Group	6	57.00	9.50		

5. Conclusion

From these studies, we conclude that, the proposed rehabilitation program using hydrotherapy, electromagnetic waves and therapeutic exercises together led to an improvement of the experimental group more than the control group in the dimensional measurements of all research variables (muscle strength working on the spine - motor range of the spine - reducing the degree of pain caused by muscle tension of the muscles lower back). These results are consistent with the results of Abbas Al-Sultani 2005, in how electromagnetic waves and exercises played an important role in improving lower back pain. Also, these results agree with the study of Abdo Asmahan in 2015, where the effect of therapeutic exercises in relieving lower back pain.

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