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Original Article

Impact of PNF Exercises in the Rehabilitation of Adolescent Girls with Osgood-Schlatter Syndrome

Prof. Dr. Abdel Haleem Yousuf[1], Assistant Prof. Mahmoud Fathy Al-Hawari [2], PhD Candidate. Samar Talaat Ahmed Abdel Latif[3]

1,2,3 Sport Health Sciences Department, Faculty of Sports Sciences, University of Sadat City, Egypt

E-mail address: samehzalam@gmail.com

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Abstract

The researcher attributes the overall improvement observed in the sample under study to a decrease in the level of muscle tension in the muscles working on the joint as a result of muscular activity due to the use of effective exercises and appropriate motor exercises, as these exercises help improve blood circulation and increase muscle strength, thereby enhancing neuromuscular coordination and increasing the speed of muscle fiber contraction. They also assist in increasing the delivery of oxygen to the tissues and enhancing the removal of muscle waste resulting from metabolism. Consequently, the exercises led to strengthening the muscles and increasing their endurance. Based on the research objective and within the scope of its proceduresit hase been concluded that the proposed program has led to a reduction in the level of pain among the sample under study. The program has proven effective, as the results showed a positive change in levels of muscle strength, flexibility, agility, and balance for the better after the application of the program compared to the previous pre-application measurements. The proposed program has contributed to alleviating the symptoms of growth center inflammation in young females.

Keywords: *Inflammation of the growth centers, Rehab.PNF, neuromuscular facilitation techniques*

Introduction

Chronic musculoskeletal pain (CMP) affects up to one-third of adolescents (10–19 years old) (Eccleston et al., 2020; Fuglkjær, Dissing, & Hestbæk, 2017; Rathleff, Roos, Olesen, & Rasmussen, 2013). During this critical period in life, pain may have a detrimental impact on a child's physical, emotional, and social functioning (Eccleston et al., 2020; Fegran et al., 2021; Khanom, McDonagh, Briggs, Bakir, & McBeth, 2020). Non-traumatic knee pain is the most common pain origin among adolescents, with Patellofemoral Pain (PFP) and Osgood-Schlatter Disease (OSD) having the highest prevalence (Rathleff et al., 2013). PFP and OSD show similar pain patterns, including pain in the anterior part of the knee, and are commonly observed among highly active adolescents (Rathleff et al., 2020a; Rathleff, Graven-Nielsen et al., 2019). PFP and OSD are often seen as self-limiting, but recent evidence shows that approximately half of

the adolescents having knee pain will continue to experience pain after 12 months, and nearly 75% of adolescents will reduce sports participation due to their knee pain (Holden et al., 2021; Rathleff, Rathleff, Olesen, Rasmussen, & Roos, 2016; Rathleff, Holden, et al., 2019). The impact of experiencing non-traumatic knee pain has significant consequences, as issues extend to basic functional tasks (running and stair-walking), shorter sleeping time, worse sleep quality, and worse quality of life (QoL) than their peers without pain (Holden et al., 2021; Mikkelsen et al., 2021; Palermo, Law, Churchill, & Walker, 2012; Rathleff et al., 2016; Rathleff, Holden, et al., 2019).

A recent individual participants meta-analysis investigating prognostic factors for long-term outcomes demonstrated that 51% of adolescents with non-traumatic knee pain still report knee pain after 12 months (Holden et al., 2021). Notably, low Health-Related Quality of Life (HRQoL) was one of the strongest prognostic factors for poor outcomes and the only identified construct that seems modifiable (Holden et al., 2021). Importantly, modifiable risk factors have high clinical value, as they might help clinicians tailor patient-centered management strategies to enhance rehabilitation success (Murillo et al., 2022). However, it is challenging to identify characteristics of predictive value, and previous evidence regarding prognostic factors in adolescents CMP is sparse and inconsistent (Holden et al., 2021; Huguet et al., 2016; Pate et al., 2020).

Despite the fact that HRQoL has been suggested as an important modifiable prognostic factor in this population, it has remained unclear which characteristics are associated with this phenomenon (Holden et al., 2021; Huguet et al., 2016). However, QoL is a multidimensional construct that is highly subjective and associated with many aspects in adolescents experiencing CMP, such as stress, loneliness, lower self-efficacy, and lower self-esteem (Karimi & Brazier, 2016; Losada-Puente, Araújo, & Muñoz-Cantero, 2020; Mikkelsen et al., 2021). Additionally, identifying ways to manage and improve QoL is ranked as a high research priority among children with CMP, which emphasizes the need for an increased understanding of what influences QoL in adolescents diagnosed with PFP or OSD (Birnie et al., 2019). This will strengthen our knowledge of this phenomenon and plausibly provide important modifiable targets for current management strategies (Pate et al., 2020).

The knee joint is the most famous joint in the field of sports and the most vulnerable to injury and knee injuries represent about 70% of injuries that affect athletes in the stadiums and there are five places in the knee that can be injured: "ligaments, cartilage, muscles around the knee, knee cover (soap) and then bones." (20: 207-210)

A study published in the British Journal of Sports Medicine indicates that 40% of knee injuries in athletes involve ligaments, and that only 11% of injuries are cartilage-related. The most common ligament injuries are anterior cruciate ligament injuries (about 50% of ligament injuries), followed by internal collateral ligament injuries, which account for 29% of ligament injuries (25).

"Mohamed Qadri Bakri and Siham Al-Sayed Al-Ghamry" (2011) and "Mohamed Adel Rushdie" (2003) indicate that rehabilitation exercises are the main axis and common factor in the treatment of injuries, which is one of the important and basic natural means in the field of integrated treatment to get rid of pain, and the rehabilitation program depends on exercises of various kinds, through the development of a program commensurate with the quality of the injury in order to raise the functional efficiency as soon as possible (21: 14) (19: 31).

The use of proprioceptive neuromuscular facilitation is a key part of the rehabilitation program to restore muscular and neurological efficiency, work to relax the muscles and improve the level of electro muscular and motor activity in them, and this type of exercise aims to reach the muscles to the highest possible level of flexibility, stretching and relaxation, which helps to build a style of compatible movement. (1: 4)

Through what was reported by previous studies and scientific references within the previous theoretical framing to the importance of muscle stretching exercises, which have importance in the prevention of injury or the development of rehabilitation programs for Osgood-Schlutter syndrome, so strength and strength exercises must be one of the basics of rehabilitation programs, which aim to maintain balance between the anterior and posterior thigh muscles and the fat muscle (25: 31)

pain pain is an unpleasant sensory and emotional experience associated with actual or actual tissue damage and its description in terms of this damage (4:96).

Osgood-Schlutter syndrome is a disorder that occurs during adolescence in the age period of (10: 15) years and one of the most important factors causing its occurrence (hormonal reasons, mechanical causes - infection or inflammation - genetic causes) and basically more than 20% of adolescent athletes and 4% of non-athletes suffer from Osgood-Schlatter syndrome. (25)

Proprioceptive neuromuscular facilitation receptors Reflexes are an effective way to help relax muscles and further lengthen them.

Bassam Abdel Majeed Mohamed Refaat (2011) idintfied the extent of the impact of the proposed program in relieving pain of the cervical vertebrae and increasing the range of motion of the spine and the extent of its impact on strengthening the muscles surrounding and opposite the cervical area and to find out whether there is a defect in the function of sensory-motor control in the spine in general and the cervical region in particular. The research sample included (30) cervical cartilage patients, and stretching exercises were used for neck muscles, ultrasound and electrical stimulation for the injured. The results of the research showed an improvement in the relief of the severity of cervical vertebral pain, improved flexibility of the cervical region and spine in all directions, and showed an improvement in the muscular strength of the cervical muscles.

Hwangbo PN, Don Kim K's study (2016) studied the effect of using neuromuscular facilities for the neck to control the trunk and maintain balance for chronic stroke patients, the study was conducted on 30 injured people and they were randomly selected and divided into two groups Equal, each group of them 15 injured, neuromuscular facilitation exercises were applied to the neck muscles on the experimental group, and a traditional rehabilitation program was applied to the control group of 15 injured. A statistically significant differences were found in all variables of the trunk weakness scale, and the overall result of the trunk control decrease scale, and the balance scale (Berg Balance) for both the experimental group and the control group, the significant differences between the two groups were found in all study variables except for the fixed sitting balance.

Malicki T, et. al. (2017) studied the results of the use of neuromuscular sensory facilities and manual therapy on patients with cervical spinal osteoporosis, where this study aimed to evaluate the effectiveness of neuromuscular sensory facilities (PNF) and manual therapy methods in the treatment of patients with osteoporosis of the cervical vertebrae, and their effectiveness in reducing pain and improving the functions of daily living; The experimental method was used and the study was conducted on 80 randomly selected princes in the age group (45-65) years, Dividing them into two groups of 40 people for each group, and to assess functional abilities, the functional classification index was used to evaluate changes in pain, The found that the neuromuscular sensory facilities group (PNF) achieved a significant improvement in the reduction in the degree of pain and improved muscle strength in the experimental group, and the PNF group showed a significant improvement in the performance of daily activities such as sleep, personal care, travel, work, entertainment, walking and standing, as well as a decrease in the intensity and frequency of pain compared to the MAN.T group. The study proved that the effectiveness of PNF use has an effect after short-term use after two weeks and long-term after three months.

Through the work of the researcher in the field of motor rehabilitation, she found that girls are exposed to Osgood-Schlutter syndrome significantly, and by referring to scientific sources, she found that girls enjoy a great deal of flexibility, thus reaching the extension of the knee joint to higher than the anatomical limits, which may mechanically cause pressure on the joint from the front angle, i.e. from the side of the tendon of the anterior quadruple muscle and in the patellar ligament, and a group of junior volleyball women were presented in the age group of (10: 15) year complain of knee pain constantly and presented to an orthopedic doctor was diagnosed knee pain Osgood-Schlutter syndrome, which often affects adolescents, especially athletes, which is characterized by the nature of their sport activities jumping and jumping and through what was highlighted by previous readings of what dealt with foreign studies of the importance of stretching and strength exercises in the rehabilitation programs of Osgood Schlatter syndrome so the researcher designed a rehabilitation program using exercises facilities neuromuscular in an attempt to reduce knee pain and improve the range of motion of the knee joint for young women injured Osgood-Schlatter syndrome.

The research problem thus crystallized in reducing knee pain and improving the range of motion of the knee joint for young female athletes suffering from Osgood-Schlatter syndrome.

The research aims to design a rehabilitation program using proprioceptive neuromuscular facilitation (PNF) exercises and to evaluate its effectiveness in treating Osgood-Schlatter syndrome among adolescent girls aged 11–15 years, by targeting the following objectives: To reduce the level of knee pain, To improve the muscular strength of the muscles surrounding the knee joint, To enhance both static and dynamic balance, To improve the range of motion (ROM) of the knee joint.

Study Hypotheses

1. There is a statistically significant difference between the pre- and post-test mean scores of knee pain, in favor of the post-test.
2. There is a statistically significant difference between the pre- and post-test mean scores of muscular strengths in the muscles surrounding the knee joint, in favor of the post-test.
3. There is a statistically significant difference between the pre- and post-test mean scores of static and dynamic balances, in favor of the post-test.
4. There is a statistically significant difference between the pre- and post-test mean scores of static and dynamic balances, in favor of the post-test.

Materials and Method

The researcher used the experimental method, and one of the experimental designs was used, which is the experimental design of one experimental group following the pre- and post-measurements.

Participants

The research community was selected from junior volleyball in the age group (11: 15) years in Cairo Governorate.

The researcher deliberately selected the research sample from the junior volleyball in the age stage (11: 15) years in Cairo Governorate with Osgood-Schlutter syndrome, who numbered (10) juniors.

Table 1. Arithmetic mean, median, standard deviation, and skewness coefficient of the descriptive variables under investigation (n=10)

Variables	Unit of measurement	Arithmetic mean	median	standard deviation	skewness
Age	Year	13	13	1.054	0.712
Length	Cm	151.7	152.5	3.974	-0.706
Weight	Kg	37.9	38.5	2.234	-0.443

It is evident from Table No. (1) the mean, standard deviation, and skewness of the descriptive variables under investigation, and the skewness coefficient ranges between (± 3), indicating the normality of the data and its adherence to the normal curve.

Criteria of Choosing the Participants:

The authors selected the participants individually based on the following criteria:

1. Young women range in age from (11: 15) years.
2. Those who have been confirmed to have Asjoud-Schlatter syndrome.
3. The approval of the research sample to conduct the research on them.
4. Regularity in the rehabilitation program. Participants must be individuals with cerebral palsy aged between 8 and 12 years.

Table 2. Arithmetic mean, median, standard deviation, and skewness coefficient of the variables under investigation. (n=10)

Variables	Units	Arithmetic mean	Median	standard deviation	skewness
Degree of pain	degree	7.9	8	0.738	0.166
Strength of the anterior quadriceps	kg	24.1	25.5	3.985	-0.316
Strength of the posterior thigh muscles	kg	18.7	19	0.675	0.434
Leg muscle strength	kg	9.4	10	0.966	-1.959
Thigh muscle circumference	degree	19.1	20	2.846	0.091
Calf muscle circumference	degree	13.3	13.5	1.494	-0.14
Knee extension angle	degree	169.3	169.5	3.743	-0.595
Knee flexion angle	degree	40.3	40.5	3.622	0.767
Fixed balance	second	0.866	1	0.29	-0.272
Moving balance	second	16.9	17	1.37	1.192
Agility	Time/degree	15.597	15.883	1.589	-0.6

It is evident from the above table (2) that the skewness coefficient ranged between (-0.334 to 0.319), which is within the range of (±3), indicating the homogeneity of the sample.

Table (3) The proposed program, the number of its units, the number of training times and the duration of the unit

No	Program	Statement
1	Total duration of Program	Three months
2	Number of Units Total	36 Units
3	the number of weekly workouts	Three times a week is
4	Unit duration	Starting from 35 s to 60 s gradually

Table (4) Time distribution of the training unit

Time Distribution	Statement
10-15 M	**warm-up**
25-35 M	**Main Part**
5-10 M	**Closing part**

Data collection

In the light of the results of the theoretical readings related to the research and according to its requirements, the researcher has conducted a reference survey for previous scientific studies and research and specialized references, which dealt with the basic axes of this research in terms of identifying the most important measurements and tests circulating and appropriate, and then the researcher has used the following tools.

The authors used a medical scale to measure weight in kilograms, Rustameter to measure the length in centimeters, Dynamometer to measure the muscular strength of the legs, Gynometer to measure range of motion, Optical symmetry scale to measure the degree of pain, Balance system, Isokintic device.

The authors also used Stopwatch, sample data and measurement registration forms, Physical tests, Multi-C device to measure muscle strength, Static balance test for hockey, Test drawn lines to measure dynamic equilibrium, Test (Zigzag running by Barrow method 3×4.5m) to measure agility.

Proposed Training Program

The time distribution of the proposed exercise program: The program was implemented over a period of (12 weeks) from Monday, 16/2/2023 to Sunday, 17/5/2023, divided into three phases. The first phase includes (12 units) and consists of muscular strength exercises for the legs and some flexibility exercises. The second phase includes (12 units) and consists of balance exercises (static and dynamic), while the third phase includes (12 units) and consists of muscular strength exercises for the legs and balance exercises (static and dynamic). The program included a total of 36 units, with three units per week, where the duration of each unit in the first phase was (35-45) minutes, with a gradual increase in the duration of the units, in the second phase (45-50) minutes, and in the third phase (50-60) minutes. Table (4) illustrates the time distribution of the program.

To design the proposed program, the researcher reviewed many specialized studies and references, as well as previous studies that addressed self-receptor training as a preventive or rehabilitative factor for the knee joint. The results were as follows: The duration of the program should be three months, The program consists of (36 training units) at a rate of (12 training units per month), (3 training units per week), The duration of each training unit

should range from (35 to 60 minutes), taking into account the principles of sports training, The sessions were held on (Saturday - Monday - Wednesday).

Objectives of the Motor Rehabilitation Program

The researcher has set the objectives that she aims to achieve through the proposed rehabilitation program as follows:

Restoration of the natural functions of the knee joint, which are represented in:

1. Minimizing the sensation of pain as much as possible.
2. Improving flexibility.
3. Enhancing the muscular strength of the thigh and calf muscles.
4. Striving to reach as close as possible to the normal state for engaging in daily life activities.

Principles of the Program

1. The opinion of the treating physician (specialist).
2. Defining the main and sub-objectives.
3. Determining the appropriate time for the program and achieving its objectives.
4. Selecting suitable exercises and identifying the specialists responsible for implementation.
5. Identifying the tools and equipment that can be utilized in the program.
6. Choosing and determining timings for testing and evaluation to ensure the accuracy and precision of program implementation and achieving results.
7. Flexibility of the program and its applicability in practice.
8. Considering the patient's suitability for treatment.
9. Considering safety and security factors.

Principles for selecting the exercises included in the program: Ensuring that the proposed exercises align with the overall objective of the program, Ensuring that the exercises are compatible with the available resources, Considering the progression in the selected exercises from easy to difficult and from simple to complex, Taking into account the element of excitement and enthusiasm through variety in exercises and avoiding boredom, Gradation in load in terms of intensity and volume through the number of repetitions and the duration of the training unit, Considering individual differences in implementing the program based on the condition, readiness, and capabilities of each participant, Flexibility of the program and its practical applicability, Specificity, where attention is given to the muscles working on the knee and leg, as well as exercises that focus on the lower abdomen, pelvis, and gluteal muscles, Motor exercises, flexibility exercises, and stretching are performed within the limits of pain.

Steps for implementing the program: Obtaining the necessary administrative approvals from the college to implement the proposed program on the sample, Defining the components of the program, the number of training units, and the duration of each unit., Pre-assessmen, Implementation of the program, post-assessment the rehabilitation method consists of

therapeutic exercises for individuals with cerebral palsy. The workload is tailored for everyone, adhering to the principle of individual differences and the severity of cerebral palsy.

The researcher developed the proposed preventive program. To achieve this, she conducted a survey of expert opinions and reviewed numerous references and studies that emphasized the necessity of developing muscular strength and balance to enhance the efficiency of the knee joint and the surrounding muscles, as well as to focus on balance, particularly to improve and increase the ability of the youth to control joint movement. Through this, the researcher found that: The necessary resources for implementing the program: There are many resources that assisted the researcher in her work, including: Balance board, Trampoline, Balance beam, Push device, Bar, Cones, Stopwatch, Sandbags, Weights, Dynamometer for assessing muscular strength

Pilot studies

The researcher enlisted the help of several graduates from the Faculty of Physical Education to assist her in conducting the exploratory study, pre-measurements, and post-measurements, after providing a complete explanation of how to conduct the tests and ensuring adherence to the test instructions for the safety and accuracy of the results.

Pre-measurements

The researcher conducted the pre-measurement of the research sample at the Recovery Center in Nasr City, Cairo, on February 11 and 13, 2023; where the researcher personally ensured the measurements were taken under the same conditions for all members of the sample in terms of (location, tools, weather conditions, and time of day).

The researcher conducted the pilot study on a random sample of (10) young women from the research community from junior volleyball with Osgood-Schlutter syndrome and from outside the basic sample, and the exploratory study was carried out in (5) five days and aimed to ensure the validity of the tools used in order to determine their validity and suitability for use, organize the measurement and registration process for each young woman, introduce young women to the measurements under research, and explain the objective of the research, and it was from Saturday 7/2/2023 to Wednesday 11/2/2023.

The Surveys resulted in identifying the validity of the place of the experiment, the response of the sample to the training program, its quality, and its suitability to the nature of the research sample, Identify the errors and difficulties that the researcher may face while conducting the basic study, Determine the number of repetitions and performance time for each of the proposed exercises and rest between each exercise, Determine the suitability and validity of the tools and devices used in the software and measurements.

Knowledge of the use and operation of the dynamometer and testing its validity and results.

Post measurement

The researcher conducted the post-measurement in the physical tests of the variables under study following the completion of the rehabilitation program on April 22 and 23, 2023.

Statistical Analysis

The researcher used the following statistical methods appropriate to the nature of the research. The researcher accepted a significance level of (0.05) and utilized the statistical program (SPSS).

- Arithmetic mean - median - standard deviation - skewness coefficient.
- Pearson's simple correlation coefficient.
- T-test for a single group.
- Rate of change.
- Cohen's effect size.

Results and Discussion

The value of "t" from the table at 9 degrees of freedom and a significance level of 0.05 is 2.262. It is evident from Table (5) that there are statistically significant differences between the pre-test and post-test means of the experimental group in all the variables under investigation and in the direction of the post-test as the calculated "t" values are greater than the table "t" value at 9 degrees of freedom and a significance level of 0.05.

Table 5. Mean of the pre-test and post-test measurements and the difference between them and the "t" values in the research variables (N = 10)

Variables	Pre-test mean	Post-test mean	Difference	Stan. dev. difference	t
Degree of pain	7.9	1.6	6.3	0.949	21
Strength of the anterior quadriceps	24.1	43.5	19.4	5.797	10.584
Strength of the posterior thigh muscles	18.7	26.2	7.5	2.173	10.914
Leg muscle strength	9.4	20.5	11.1	3.573	9.824
Thigh muscle circumference	19.1	29	9.9	7.767	4.031
Calf muscle circumference	13.3	17.6	4.3	3.561	3.819
Knee extension angle	169.3	175.3	6	4.807	3.947
Knee flexion angle	40.3	28.3	12	4.922	7.71
Fixed balance	0.866	2.429	1.563	0.75	6.594
Moving balance	16.9	13.2	3.7	2.452	4.772
Agility	15.597	10.559	5.038	2.465	6.463

It is evident from the table (6) that: There is a change resulting from the application of the proposed program under investigation ranging from (3.67% to 180.48%), There is a clear effect on all variables resulting from the application of the proposed program, as the value of (ETA2) ranges between (1.119 and 6.1), indicating that the level of impact is significant since these values are greater than (0.80).

Table 6. Pre-test and post-test mean, the difference between them, the rate of change, and "eta2" values in the research variables (N = 10)

Variables	Pre-test mean	Post-test mean	Difference	rate of change	ETA2
Degree of pain	7.9	1.6	6.3	79.75%	6.641
Strength of the anterior quadriceps	24.1	43.5	19.4	80.50%	3.347
Strength of the posterior thigh muscles	18.7	26.2	7.5	40.11%	3.451
Leg muscle strength	9.4	20.5	11.1	118.09%	3.107
Thigh muscle circumference	19.1	29	9.9	51.83%	1.275
Calf muscle circumference	13.3	17.6	4.3	32.33%	1.208
Knee extension angle	169.3	175.3	6	3.54%	1.248
Knee flexion angle	40.3	28.3	12	29.78%	2.438
Fixed balance	0.866	2.429	1.563	180.48%	2.085
Moving balance	16.9	13.2	3.7	21.89%	1.509
Agility	15.597	10.559	5.038	32.30%	2.044
Cohen's effect size	**Small**	**Medium**	**Big**		
	0.20:0.49	**0.50:0.79**	**≥0.80**		

There are statistically significant differences between the means of the pre-test and post-test measurements in the improvement of pain level, muscle strength, static and dynamic balance, agility, and the size of the muscles acting on the knee joint, in favor of the post-test measurement, where the percentage of improvement ranged between (3.67%: 180.48%). The researcher attributes this progress to the proposed program, which included structured exercises aimed at developing elements of strength, flexibility, balance (both static and dynamic), and agility for various muscle groups acting on the knee joint, whether for the development of the anterior, posterior, or lateral muscles of the sample under study. The researcher believes that the development of leg muscle strength is followed by the enhancement of static and dynamic balance, as overall balance for the legs requires strong muscle groups surrounding the joint, and the repetition of balance training for the legs significantly contributes to improving and developing leg muscle strength, indicating that balance and muscle strength are two important and influential factors that affect each other.

This is confirmed by the studies of both Mohamed Mahmoud Al-Sayed Omar (2014), Mohamed Ismat Al-Husseini (2013), Ihab Mustafa Kamel (2007), and Yasser Said Shafie (1993), which state that it is essential to coordinate and harmonize the training of the muscle groups surrounding the joint that the joint operates on, significantly contributing to the protection and prevention of the joint from injuries in general. This is also affirmed by "Abu Al-Ala Abdel Fattah and Ibrahim Shaalan" (1994), who state that physical fitness is related to the health of athletes and helps them in prevention, treatment, and rehabilitation, as well as reflecting the body's efficiency in meeting the demands of sports activity. Attention to elements of physical fitness for athletes, such as strength, balance, flexibility, and explosive power, among others, contributes to a decrease in the rate of sports injuries.

Balance also interacts with strength and capacity training in an integrated manner, which affects the excitability of autoreceptors, leading to the smooth transmission of nerve impulses through the nervous system, resulting in a high level of neuromuscular control that enhances balance. This means that the relationship involves the integration between the nervous system and the muscular system, leading to the secretion of the appropriate amount of the hormone (acetylcholine), which in turn regulates muscle function and the force of muscle contraction necessary for achieving balance.

The researcher attributes the overall improvement observed in the sample under study to a decrease in the level of muscle tension in the muscles working on the joint as a result of muscular activity due to the use of effective exercises and appropriate motor exercises, as these exercises help improve blood circulation and increase muscle strength, thereby enhancing neuromuscular coordination and increasing the speed of muscle fiber contraction. They also assist in increasing the delivery of oxygen to the tissues and enhancing the removal of muscle waste resulting from metabolism. Consequently, the exercises led to strengthening the muscles and increasing their endurance, which in turn increases joint flexibility and the range of motion, as there is a close relationship between joint flexibility and the ability of muscle fibers to stretch. When there is a limitation in the range of motion of the joint, it may cause a restriction in the extent to which the working muscle fibers can stretch. The researcher observes that the improvement in the range of motion has led to the alleviation of muscle tension and an increase in the level of muscle and ligament relaxation, thereby enhancing their length. This allows for the use of joints at a greater angle, enabling the muscles to produce a larger range of motion due to the application of appropriate exercises, which are considered effective positive therapeutic methods. Furthermore, their therapeutic effects last for extended periods. The stretching achieved by the sample under study was positive, which may explain the improvement in the range of motion, as confirmed by the study of Iqbal Rasmi (2009).

As "Izzat Al-Kashef (2018) explains, therapeutic exercises help eliminate cases of functional impairment in the affected area by caring for the muscles, ligaments, and joints, and paying attention to the mechanics of body movements and posture in order to restore the natural

state of body balance. They also have accompanying functional effects that increase blood circulation and metabolic processes, which aids in the delivery of more nutrients and oxygen to the injured area through blood flow, thereby strengthening the muscles and eliminating the remnants of the injury. Additionally, they improve muscle sensation by moving the joints and contracting the working muscles, while also mitigating the negative effects resulting from passive rest (clinical) and its impact on vital systems.

This is also consistent with the results of the study by "Ahmed Mohamed Said" (2004) and "Abdul Majid Abdul Fattah Awad" (2003), which demonstrated the success of rehabilitation exercises in restoring muscle strength in the muscle groups affected by injury.

This aligns with the study by Rainvill and Hartigan (2003), which demonstrated that reducing pain-related disability by alleviating the fear associated with spinal movement through regular exercise at each stage within the available range of motion is effective.

Furthermore, Qudri Bakri and Sihem Al-Ghamri (2011) confirmed that the use of various types of physical therapy, whether through physical exercises, play, swimming, or others, all contribute to strengthening and improving the patient's overall condition, in addition to increasing their awareness and perception of various matters, especially those related to their environment, both human and spatial, aided by the effects resulting from physical therapy.

The results also concurred with the findings of the studies by Islam Mohammed et al. (2010) and Ihab Mustafa Kamel (2007), indicating that the use of neuromuscular facilitation exercises for sensory receptors in its various methods is more effective in increasing the range of motion and contributes to the development of both muscular strength and capacity, flexibility, coordination, agility, and both static and dynamic balance.

Michael J. Alter (2004) indicates that the use of neuromuscular facilitation techniques for sensory receptors, through its various methods, significantly enhances and improves the range of motion compared to other stretching methods and increases strength. This is because elasticity without strength may expose an individual to joint injuries, and the application of these techniques and methods is beneficial in preventing sports injuries by developing both strength and elasticity together. Additionally, it aids in good muscle relaxation.

Frederick (2001) confirms that one of the advantages of neuromuscular facilitation methods for sensory receptors (repeated contractions, slow reciprocal contraction with stabilization) helps in developing balance and strength, and increasing the range of motion, which leads to improved movement.

Through the presentation, it is evident that the use of proprioceptive neuromuscular facilitation (P.N.F) exercises within the therapeutic physical activity program has led to better

results in improving muscle strength, flexibility, and range of motion, as demonstrated by the differences in measurements favoring the post-measurement; this validates the research hypothesis. Thus, the researcher has confirmed the validity of the research hypotheses.

Conclusion

Considering the study's objectives, questions, the scope of the study, and the nature of the sample, and based on the results and data collected, as well as the statistical treatments used, the researcher reached the following conclusions:

1. The proposed program has led to a reduction in the level of pain among the sample under study.
2. The program has proven effective, as the results showed a positive change in levels of muscle strength, flexibility, agility, and balance for the better after the application of the program compared to the previous pre-application measurements.
3. The proposed program has contributed to alleviating the symptoms of growth center inflammation in young females.

Recommendations

Based on the study's results and the conclusions drawn, the researcher recommends the following:

1. The use of the proposed program in rehabilitating those affected by growth center inflammation.
2. The recommendation to work on establishing other rehabilitation programs for those affected by growth center inflammation.
3. The recommendation for further research to rehabilitate those affected by growth center inflammation at various age stages.

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