Determining an effective method for preventing shoulder pain induced by wheelchair basketball.

Abstract : *Introduction : Wheelchair basketball is played on the same court and follows the same rules as basketball, except that players use wheelchairs for mobility. Like all physical activities and sports, it can cause injuries and health problems. Objective : The aim of our study was to evaluate the effectiveness of three (3) prevention methods for shoulder pain in wheelchair basketball players through a protocol combining several means. Methods: The intervention involved 35 players divided into 3 groups: a control group (CG) where muscle strengthening (MS) sessions were administered 3 times per week, an experimental group (GE2) which, in addition to the 3 MS sessions, benefited from a transcutaneous electrical nerve stimulation (TENS) program at the end of each session, and a third experimental group (GE3) which, in addition to the 3 MS sessions, had a cryotherapy session at the end of the sessions. Results: The muscle strengthening programs combined with electrical stimulation or cryotherapy showed significant effectiveness in preventing shoulder pain in participants with a significant difference (with p = 0.026 and p = 0.007 respectively). Conclusion : These programs can be integrated into training planning for effective prevention of shoulder pain.*

Keywords : *Wheelchair basketball, shoulder pain, prevention*

Introduction

Sports participation for people with disabilities is of major importance as it is one of the main pillars for maintaining physical and mental well-being. Disability sports are thus a means for people with disabilities to assert themselves in sports. Wheelchair basketball is the most widely practiced team sport worldwide and in Burkina Faso. Like all sports, practicing wheelchair basketball can lead to injuries and musculoskeletal pain in the upper limbs, which are subjected to overuse [1,2]. However, practicing wheelchair basketball requires a suitable environment and good physical condition for wheelchair maneuverability and gameplay. Since the upper limbs play both a propulsive and a gestural role, the shoulder, being the most solicited joint, is prone to overuse. In Burkina Faso, the frequency of shoulder pain is high (70.6%) [3]. The main risk factors were the participants' age, number of years of experience, profession, physical capacity, and the quality of wheelchairs and training grounds [3]. Additionally, the overuse of the wheelchair athlete's shoulder makes this joint vulnerable. The injuries associated with shoulder pain identified in wheelchair basketball players are tendinous lesions (72%) [3]. These lesions affected the tendons of the rotator cuff muscles and the long biceps tendon. The identification of these lesions using ultrasound allowed for individualized and collective management of wheelchair basketball players. The aim of this study was to evaluate the effectiveness of three (3) methods of preventing shoulder pain in wheelchair basketball players through a protocol combining several means.

Materials and Methods

1. Setting and study design

This was an intervention study. It took place on the training grounds of the Burkina Faso Association for Adapted Sports (ABUSA) and Handicap Solidaire in Ouagadougou and Kassibana in Bobo-Dioulasso for the experiments. The Physical Medicine Department of the University Hospital Center of Bogodogo (CHU-B) (Burkina Faso) contributed to the study in terms of equipment and human resources for physiotherapy. The Teaching and Research Unit of Deficiencies, Adapted Physical Activities and Rehabilitation of the National Institute of Youth, Physical Education and Sports (INJEPS) of the University of Abomey-Calavi (UER: DAPAR/INJEPS/UAC) in Benin served as a framework for data analysis and processing.

2. Study population and sample

2.1Study population

The study population consisted of players from ABUSA and Handicap Solidaire in Ouagadougou and players from Kassibana in Bobo-Dioulasso, given the regularity of their training sessions and their participation in national championships. These three sports associations are equipped with locally designed basketball wheelchairs and their training grounds did not present any obstacles to the practice of wheelchair basketball. All wheelchairs used came from the workshop of the association Fauteuils Roulants au Sud (FRS) active in Burkina Faso.

2.2 **Study sample** The sample (n = 35) for the study was composed of players with or without shoulder pain from the 3 wheelchair basketball sports associations. However, participants had to meet the following criteria: Inclusion criteria

- Have a license affiliated with the Paralympic Committee;
- Be male. Exclusion criteria
- Not have participated in at least one week of training. All players from each team participated adequately in the experiment without distinction. The inclusion and exclusion criteria were taken into account during data processing.

3. Materials and techniques

For data collection, the following instruments were used:

- Data collection sheets to record the individual data of the players;
- A self-administered questionnaire of the shoulder pain scale for wheelchair basketball players;
- A graduated ruler from 0 to 10 cm for assessing pain intensity on a visual analog scale (VAS);
- A 4-channel Globus stimulator for transcutaneous stimulation. Stimulation conditions: Participants remained seated in their wheelchairs. The 3 sessions were placed immediately after training. At least 4 electrodes were placed on the pain sites following the model indicated on the electrostimulator notice. Also, a pen for finding the motor points of the muscles concerned was used to optimize the contraction produced and minimize discomfort [4,5]. The electrodes used were 5 cm x 5 cm (small electrodes) and 8 cm x 5 cm (large electrodes). For electrode placement, the targeted muscles were the deltoid, trapezius, and pectorals (Photo 10). The GLOBUS Elite endorphin TENS program was used. Depending on the sensitivity of the participants, the current intensity varied from 10 to 12 mA. The duration of the stimulation sessions was 40 minutes.
- Alcohol and cotton wool, to clean the skin and promote good electrical conductivity;
- An infrared lamp of the Beurer brand to warm up and relax the stimulated areas;
- Ice cubes and towels for cryotherapy sessions. For cryotherapy sessions, participants were seated in their wheelchairs. Ice cubes wrapped in a wet towel were placed on the painful site of the shoulder for 15 minutes [6].
- Elastic bands and dumbbells (3kg) for the muscle strengthening program.

4. Experimental protocol

The participants were divided into 3 experimental groups to assess and compare the intensity of shoulder pain and physical capacity (aerobic capacity, speed, and upper limb strength) according to the training modalities for a period of 8 weeks. During this period, the effects of a designed stretching and muscle strengthening program, electrostimulation, and cryotherapy were evaluated.

- **Program 1 : Control Group (CG)**

  This program consisted of a 15-minute warm-up, ten (10) laps of the basketball court, followed by 5 minutes of global stretching. Then, participants performed ten (10) muscle strengthening exercises, including 5 exercises with dumbbells and 5 exercises with elastic bands for about 30 minutes. Finally, participants did 15 minutes of specific basketball exercises and played 2 x 20 minutes of matches and 5 minutes of relaxation.

- **Program 2 : Experimental Group 1 (EG1)**

  This group followed Program 1 and additionally received an electrostimulation session 3 times per week, immediately after the training session. Each session included a 40-minute electrostimulation phase followed by infrared relaxation and a 5-minute light massage [7]. For electrostimulation, the TENS analgesic program was used for pain management. Depending on the sensitivity of the participants, the current intensity varied from 10 to 12 mA.

- **Program 3 : Experimental Group 2 (EG2)**

  This group followed Program 1 and additionally received a cryotherapy session at the end of each training session : (local application of ice). For cryotherapy sessions, ice cubes were wrapped in a wet towel and placed on the painful part of the shoulder for 20 minutes. During the session, participants were seated in their wheelchairs.

An initial evaluation was conducted at the beginning (Ti) and a final evaluation (Tf) at the end of the 8 weeks. These programs were experimented with at the beginning of the sports season in the physical preparation phase of the athletes.

5. Study Variables

- **Dependent variables :**
  - Pain intensity: Visual Analog Scale (VAS)
  - Physical capacity: Endurance, strength, speed
- **Independent variables :**
  - Type of physiotherapy programs : muscle strengthening program, muscle strengthening program plus electrostimulation, muscle strengthening program plus cryotherapy.

6. Statistical Analysis

Data was entered into Excel (Microsoft Office Excel 2010). Statistical analyses were performed using SPSS software (version 25). Comparisons of means were conducted. The Wilcoxon signed-rank test and the Kruskal-Wallis test for independent samples were used to test the hypothesis of equality of means. Significance was set at $p < 0.05$.

7. Ethical Considerations

Before the start of this study, authorization from the national ethics committee for health research in Burkina Faso was obtained. Administrative authorizations were obtained from the heads of sports organizations (federations and sports associations concerned). Before participating in this study, all participants gave their written consent after a detailed written and oral explanation of the benefits and constraints associated with participating in this study, in accordance with the recommendations of the 2013 Declaration of Helsinki [8]. Participants had the option to withdraw from the study at any time. The study was placed under the supervision of the Physical Medicine Department of the University Hospital Center of Bogodogo (CHU-B) in Burkina Faso and the deontological rules of this institution were respected.

Results

1.General characteristics of participants

Participants had a mean age of 36.2 ± 5.6 years with 10.8 ± 5.9 years of experience in wheelchair basketball. In general, they were people living with the sequelae of poliomyelitis with a mean body mass of 60.5 ± 10.4 kg and a mean sitting height of 80.5 ± 4.5 cm. The general characteristics of the participants are shown in Table I.

Table I : General characteristics of participants

	Min	Max	m	S
	N=35			
Age (years)	25	49	**36,2**	5,6
Nb_Yr_exp (years)	5	23	10,8	5,9
M_corp (kg)	42	93	60,5	10,4
S_H (cm)	74	94	80,7	4,6

N: sample size; Min: minimum; Max: maximum; m: mean; s: standard deviation; Nb_Yr_exp: number of years of experience; M_corp: body mass; S_H: seated height

2.1. Effect of the control program

The control group benefited from a muscle strengthening program only, administered 3 training sessions per week. The comparison of initial and final measurements of pain intensity and physical capacity was made using the Wilcoxon signed-rank test. The results showed a significant difference in speed and shoulder pain intensity (p=0.027 and p=0.041 respectively). Table II shows the results of the comparison of initial and final measurements for the control group.

Table II : Comparison of initial and final measurements of the control group

	MI	MF	Δ	%Amél.	**Sig. (bilat)**
	m ± s ; n= 12				
Mov_ speed (s)	**5,6** ± 0,6	**5,41** ± 0,5	**0,20*** ± 0,08	**3,6**	0,027
Yoyo_Test(m)	550,8 ± 139,2	613,33 ± 211,54	62,50 ± 47,4	11,3	0,288
Pass_ max (m)	15,5 ± 2,1	13,04 ± 1,97	0,29 ± 0,5	2,3	0,170
Int_sh_ pain (cm)	**3,9** ± 0,99	**2,67** ± 2,18	**0,75*** ± 0,5	**31,9**	0,041

MI: initial measurement; MF: final measurement; Δ: mean; s: standard deviation; %Improved: percentage of improvement = (Intensity2 – Intensity1) x100 / Intensity1; Sig.: significance; n: number of group 2; Mov_ speed (s) : Movement speed in seconds ; Yoyo test: Yoyo test distance in meters; Max_pass: maximum pass distance in meters; Int_sh_ pain (cm): Intensity of shoulder pain in centimeters. Significance P = 0.05

2.2. Effect of Program 2 : muscle strengthening + electrostimulation

In the experimental group 2, two programs were administered: a muscle strengthening program and an electrostimulation program. The comparison of measurements before and after the intervention showed significant differences for speed (p=0.036) and shoulder pain intensity (p=0.004).

Table III : Comparison of initial and final measurements of experimental group 2

	MI	**MF**	**Δ**	**%Improv.**	**Sig.**
		m ± s ; n= 11			
Mov_ speed (s)	5,2 ± 0,5	5,00 ± 0,4	**0,22*** ± 0,09	**4,2**	0,036
Yoyo_Test(m)	888,2 ± 222,3	859,1 ± 29,4	-29,1 ± 52,2	-3,3	0,722
Pass_ max (m)	12,2 ±2,5	12,5 ± 2,9	0,29 ± 0,26	2,4	0,475
Int_sh_ pain (cm)	5,0 ± 1,34	3,1 ±1,37	**1,91*** ± 0,28	**38,2**	0,004

MI: initial measurement; MF: final measurement; Δ: mean; s: standard deviation; %Improved: percentage of improvement = (Intensity2 – Intensity1) x100 / Intensity1; Sig.: significance; n: number of group 2; Mov_ speed (s) : Movement speed in seconds ; Yoyo test: Yoyo test distance in meters; Max_pass: maximum pass distance in meters; Int_sh_ pain (cm): Intensity of shoulder pain in centimeters. Significance P = 0.05

2.3. Effect of Program 3 : muscle strengthening + cryotherapy

The experimental group 3 benefited from a muscle strengthening program and cryotherapy. The comparison of the two measurements showed a significant difference only in shoulder pain intensity (p=0.002). Table IV give this comparison.

Table IV : Comparison of initial and final measurements of experimental group 3

	MI	MF	Δ	**%Improv.**	**Sig.**
	m ± s ; n= 12				
Mov_ speed (s)	5,9 ± 0,42	5,5 ± 0,4	0,17 ± 0,08	2,9	0,052
Yoyo_Test(m)	666,7 ± 198,0	733,3 ± 249,9	66,67 ± 50,80	10	0,169
Pass_ max (m)	11,3 ± 1,5	11,8 ± 1,6	0,43 ± 0,21	3,8	0,054
Int_sh_ pain (cm)	4,8 ± 1,8	2,58 ± 2,1	**2,17*** ± 0,24	**45,7**	0,002

MI: initial measurement; MF: final measurement; Δ: mean; s: standard deviation; %Improved: percentage of improvement = (Intensity2 – Intensity1) x100 / Intensity1; Sig.: significance; n: number of group 2; Mov_ speed (s) : Movement speed in seconds ; Yoyo test: Yoyo test distance in meters; Max_pass: maximum pass distance in meters; Int_sh_ pain (cm): Intensity of shoulder pain in centimeters. Significance P = 0.05

2.4. Comparison of the three intervention programs

The three programs to be evaluated were: program 1 (muscle strengthening), program 2 (muscle strengthening + electrostimulation) and program 3 (muscle strengthening + cryotherapy). The independent samples test was used for comparisons. The Kruskal-Wallis test for independent samples for the hypothesis of equality of means showed a significant difference in the decrease of shoulder pain intensity (p = 0.013). The figure below shows the results of this comparison.

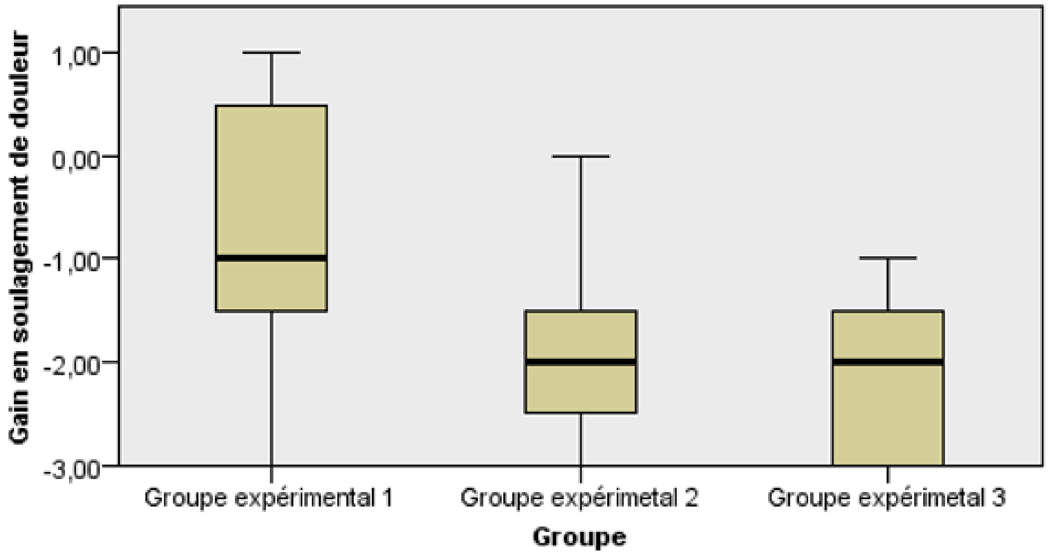

Figure : **Comparison of the three intervention programs**

2.5. Comparison of the control group program (MS) with the experimental group 2 (MS + TENS)

A pairwise comparison of the control group program (MS) with the experimental group 2 (MS + TENS) showed a significant difference in pain intensity at p=0.026. This comparison is shown in Table V.

Table V : Comparison of the MS and MS+TENS programs

	CG (n= 12)	**EG2 (n= 11)**	**Sig**
	Δ (**m** ± s)		
Mov_ speed (s)	-0,20 ± 0,08	-0,22± 0,09	0,934
Yoyo_Test (m)	62,50 ± 47,42	-29,09 ± 52,21	0,573
Max_pass (m)	0,29 ± 0,45	0,29 ± 0,26	0,750
Int_sh_ pain (m)	-1,25 ± 0,51	-1,91 ± 0,28	**0,026**

CG : control group ; EG : experimental group ; m : mean; s: standard deviationtion; Sig.: significance; n: group size; Mov_ speed (s) : Movement speed in seconds ; Yoyo_test: Yoyo test distance in meters; Max_pass: maximum pass distance in meters; Int_sh_ pain (cm): Intensity of shoulder pain in centimeters. Significance P = 0.05

2.6. Comparison of the control group program (MS) with the experimental group 3 (MS + Cryotherapy)

A comparison of the control group program (MS) with the experimental group 3 (MS + cryotherapy) showed a significant difference in pain intensity at p=0.007. Table VI shows the comparison of mean values added after the experiment.

Table VI : Comparison of the MS and MS+Cryotherapy programs

	CG (n= 12)	**G E3 (n= 12)**	**Sig**
	Δ (**m** ± s)		
Mov_ speed (s)	-0,20 ± 0,08	-0,17 ± 0,08	0,934
Yoyo_Test (m)	62,50 ± 47,42	66,67 ± 50,80	0,573
Max_pass (m)	0,29 ± 0,45	0,43 ± 0,21	0,750
Int_sh_ pain (m)	-1,25 ± 0,51	-2,17 ± 0,24	**0,007**

CG : control group ; EG : experimental group ; m : mean; s: standard deviationtion; Sig.: significance; n: group size; Mov_ speed (s) : Movement speed in seconds ; Yoyo_test: Yoyo test distance in meters; Max_pass: maximum pass distance in meters; Int_sh_ pain (cm): Intensity of shoulder pain in centimeters. Significance P = 0.05

2.7. Comparison of the experimental group 2 program (MS + TENS) with the experimental group 3 (MS + Cryotherapy)

No significant difference was observed between experimental groups 2 and 3. Table VII illustrates the results of the comparison.

Table VII : Comparison of the MS+TENS and MS+Cryotherapy programs

	G E2 (n= 11)	**G E3 (n= 12)**	**Sig**
	Δ (**m** ± s)		
Mov_ speed (s)	-0,22± 0,09	-0,17 ± 0,08	0,934
Yoyo_Test (m)	-29,09 ± 52,21	66,67 ± 50,80	0,573
Max_pass (m)	0,29 ± 0,26	0,43 ± 0,21	0,750
Int_sh_ pain (m)	-1,91 ± 0,28	-2,17 ± 0,24	0,54

EG : experimental group ; m : mean; s: standard deviationtion; Sig.: significance; n: group size; Mov_ speed (s) : Movement speed in seconds ; Yoyo_test: Yoyo test distance in meters; Max_pass: maximum pass distance in meters; Int_sh_ pain (cm): Intensity of shoulder pain in centimeters. Significance P = 0.05

Discussion

The mean intensity of shoulder pain was 4.54 on the VAS. This shoulder pain is one of the limiting factors in the observed performance of physical capacity. Management programs for wheelchair athletes therefore aim at a dual objective : strengthening the muscles of the upper limbs and trunk and protecting the shoulder joint complex, the main joint that ensures movement. A literature search has supported that strength training can reduce shoulder complaints in wheelchair athletes [10]. The intervention aims to improve physical capacity associated with physiotherapy as a means of reducing pain intensity in wheelchair basketball players. A recent study confirms that chronic shoulder injuries are a major obstacle to the performance of athletes in water sports and arm sports [11].

Program 1 (muscle strengthening only) of the control group 1 showed a significant difference in movement speed and shoulder pain intensity (p=0.027 and p=0.041 respectively). The significant improvement in movement speed was 3.6% and 31.9% for shoulder pain relief. The explosive strength of the upper limbs and aerobic capacity did not show significant results. These results corroborate those of Ozmen et al. [17] who showed that six weeks of strength training significantly increases sprint performance in wheelchair basketball athletes. Gremion et al. [18] conclude that muscle strengthening exercises improve the synthesis of collagen fibers and thus reduce the intensity of pain. Thus, the improvement in the physical properties of muscle fibers could explain the increase in physical capacity, particularly in the movement speed of participants.

Previous studies have evaluated muscle strengthening programs for the prevention of shoulder pain and injuries. A 6-week program showed significant improvements in shoulder range of motion in swimmers [19]. However, another study evaluated an 18-week program and found non-significant results in handball players [20], suggesting that improvements in physical capacity depend on other factors as well.

In wheelchair basketball, studies have evaluated muscle strengthening programs over six weeks, three times per week. A study that measured shoulder pain intensity and quality of life in participants (N=6) found no significant improvement [21]. Another study, in a 6-week stretching and strengthening program, measured the range of motion and strength of internal and external shoulder rotator muscles (N=7). The results showed a significant improvement in joint range of motion compared to strength [22]. Saleky et al. [23] recently evaluated the effect of a 10-week exercise program on shoulder pain and range of motion in elite wheelchair basketball players. These results showed a significant improvement in shoulder extension and a non-significant decrease in pain index. A review of literature on the effectiveness of physiotherapy treatment for subacromial pain states that exercise treatment improves pain intensity and shoulder function [24]. An 8-week stretching and strengthening program can significantly reduce the risk factors for shoulder pain or injury in wheelchair basketball players. The significant decrease in pain intensity improves sports movements and consequently the performance of participants.

Regarding experimental program 2, it consists of a combination of muscle strengthening and electrostimulation. The results of this study, comparing the two measurements (initial and final), showed a significant difference in speed (p=0.036) in terms of physical capacity, as well as in shoulder pain intensity (p=0.004). This program improved movement speed and reduced shoulder pain intensity in participants. A 38.2% improvement in pain relief was observed. Zhou et al. [25] demonstrated the effectiveness of TENS for pain and mobility in hemiplegic shoulders. A systematic review synthesizing studies on the effectiveness of electrotherapy for rotator cuff diseases shows that it has short-term benefits for pain and does not have adverse effects [26]. This analgesic effect of transcutaneous electrical nerve stimulation is explained by the production of endorphins, which regulate the endogenous mechanism of pain perception [27]. Previous studies have shown that transcutaneous electrical nerve stimulation increases pain threshold and/or pain tolerance [28,29]. These studies suggest that endorphin production is increased by 22% compared to baseline levels. These are endogenous substances containing substance P (mediator and modulator of nociceptive impulses), purines, and opioids (inhibitors), such as endorphins, enkephalins, and dynorphins (morphine-like substances) that are natural analgesics [30].

As for the improvement in participants' physical capacity, this study showed a non-significant improvement in the explosive strength of the dominant arm and a significant increase in movement speed. Adjenou et al. [31] have proven that electrical stimulation is a means of developing certain functional characteristics of the muscle in INJS students. Studies have also shown its analgesic effect in musculoskeletal pain [32–34]. However, its effectiveness compared to drug therapies or other interventions remains controversial in the literature [35]. A recent study shows that TENS has a short-term effect in the conservative treatment of rotator cuff lesions [36].

Concerning program 3 (muscle strengthening + cryotherapy), the initial and final measurements showed a significant difference in shoulder pain intensity (p=0.002). The evaluation of program 3 showed a non-significant improvement in the physical capacity of the participants. However, the program reduced shoulder pain with a 45.7% relief. The addition of cryotherapy was effective in relieving shoulder pain in participants. Cryotherapy promotes pain reduction and improves recovery by increasing blood flow to the treated area. Our results corroborate those of Lisinski et al. [37] who reported that cryotherapy is a treatment of choice for shoulder pain, in a clinical study. A study has shown that cryotherapy or cold therapy is a conservative treatment for shoulder pain [38]. It is a treatment aimed at maintaining physiological functions in a satisfactory state when it is not essential to treat the causes of the disease directly, or when it is no longer possible to do so [39].

Also, a clinical trial compared cryotherapy and strengthening exercises in patients suffering from rotator cuff tendinopathy and found no significant difference between the two programs in terms of strength, range of motion, and pain [6]. A comparative study in baseball athletes showed that light exercises with ice treatment had a significant effect on shoulder pain compared to ice treatment alone or light exercises alone [40].

In general, physiotherapy coupled with muscle strengthening exercises gives better results, especially in relieving shoulder pain.

When comparing these three intervention programs, Program 1 resulted in a 31.9% improvement in shoulder pain ; Program 2, 38.2% ; and Program 3, 45.7%. The comparison of means test showed a significant difference in pain relief among the 3 experimental protocols ($p = 0.013$). This indicates that the additive effect of physiotherapy combined with muscle strengthening significantly contributed to pain relief. Since the primary goal was to alleviate pain, the addition of physiotherapy (TENS or cryotherapy) was necessary to improve physical capacity. The analgesic effect of TENS and cryotherapy on pain was observed in the short term. This short-term effect of physiotherapy can be explained by the production of endogenous analgesic substances stimulated by the passage of electric current (electrostimulation) [27] and by the increased blood flow to the treated area (cryotherapy). Long-term pain control is contingent on muscle strengthening exercises, which improve muscle quality [18].

Programs 2 (muscle strengthening + TENS) and 3 (muscle strengthening + cryotherapy) demonstrated their effectiveness in relieving shoulder pain in participants. Pain control is important in a training program, as it facilitates improvements in physical capacity. Improved physical capacity contributes to achieving performance goals, which is beneficial for athlete preparation. Program 3 would be more advantageous because, in addition to pain relief, cryotherapy promotes physical recovery by improving muscle oxygenation and reducing the onset of muscle soreness. Dupuis et al. [6] have shown that cryotherapy improves pain symptoms and shoulder function in the management of rotator cuff tendinopathy. This offers an advantage during competition periods.

Therefore, Program 3 can be incorporated into training cycles to prevent pain in wheelchair basketball players in Burkina Faso. This choice is motivated by the program's easier adoption by athletes as it is accessible to all.

Limitations of the study

The limited sample size also did not make it possible to evaluate the effect of a program combining muscle strengthening, TENS and cryotherapy which could make it possible to appreciate the different programs even more.

Conclusion

This experimental study evaluated three programs for preventing shoulder pain in wheelchair basketball players in Burkina Faso. These programs showed varying degrees of effectiveness in the experimental groups, offering opportunities for their integration into training programs to improve physical capacity and prevent secondary shoulder pain in participants.

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