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Effectiveness of Cryotherapy on the Physical Recovery Process of Boccia Athletes with Cerebral Palsy Spastic

Rico Anandri S, Umi Budi Rahayu*, Suryo Saputra Perdana
Physioterapy Study Program, Faculty of Healty Sciences, Muhamadiyah University Surakarta, Indonesia
J128240001@student.ums.ac.id, umi.budi@ums.ac.id*, ssp741@ums.ac.id
*Correspondence

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Abstract
Introduction: *Cerebral palsy (CP) is a non-progressive neuromotor disorder that causes increased muscle tone and impaired motor control, thus affecting functional ability and participation in adaptive sports such as Boccia. One of the main challenges in athletes with spastic cerebral palsy is the slow recovery of muscles due to spasms and fatigue. Cryotherapy is used in rehabilitation to lower spasticity, but scientific evidence on Boccia athletes is still limited.* ***Objective:*** *this study was to analyze the effectiveness of cryotherapy on the physical recovery process in Boccia athletes with spastic cerebral palsy.* ***Methods:*** *Pre–post experimental research without a control group in 18 Boccia athletes aged 18–35 years. Local cryotherapy is administered to the extremities for four weeks with a frequency of three times per week. Measurements were made using the Modified Ashworth Scale (MAS), hand-held dynamometer, and Borg Rating of Perceived Exertion (RPE).* ***Results and Discussion:*** *Results showed a 26% decrease in muscle tone, a 14% increase in muscle strength, and a 15% decrease in fatigue perception after cryotherapy. Physiologically, this effect is related to decreased stretch reflex activity and increased neuromuscular efficiency due to local vasoconstriction and slowing down of nerve conduction.* ***Conclusion:*** *Cryotherapy effectively accelerates the physical recovery of Boccia athletes with spastic CP through improvements in muscle tone, strength, and fatigue.*

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Introduction

Cerebral palsy (CP) is a non-progressive neuromotor disorder that appears in childhood and has a significant impact on the control of movement, muscle tone, and motor function of individuals (Afifah et al., 2024); (Muna, Naufal, & Rahman, 2023). This condition remains one of the leading causes of physical disabilities in children worldwide. The prevalence of CP is estimated to range from 2–3 cases per 1,000 live births and has been relatively stable in the last two decades (Karunianingsih, Kushantoro, & Lowing, 2025). However, the development of diagnosis and therapy shows an increased understanding of the various comorbidities that accompany CP, such as spasticity, muscle weakness, balance disorders, and mobility limitations (Jiang, Yang, Chen, Song, & Zhang, 2024).

Spastic type CP is the most common form found, characterized by increased muscle tone, excessive stretch reflexes, and resistance to passive movement (Rukmini, Zahro, Isnaini, Anggreani, & Qhomariyah, 2022). This condition can cause musculoskeletal deformity, limited range of motion, and decreased quality of life (Paul, Nahar, Bhagawati, & Kunwar, 2022). Therefore, an effective rehabilitative approach is urgently needed to optimize motor function, slow down secondary complications, and increase the social participation of people with CP. In the context of modern rehabilitation, adaptive sports like Boccia has become one of the important means to improve the functional and psychosocial abilities of individuals with CP. Boccia is a precision sport designed specifically for individuals with severe motor impairments and has become an official branch of the Paralympic events. This activity not only trains coordination and motor control, but also improves social interaction, independence, and mental health of participants. Nevertheless, Boccia athletes with spastic CP still face challenges in the physical recovery process after competitive activities, such as prolonged muscle spasms, fatigue, and longer recovery times compared to athletes without disabilities.

Cryotherapy is one of the physiotherapy modalities that is widely used to accelerate physical recovery after intensive exercise. The therapy works through a decrease in tissue temperature that causes a local vasoconstrictor effect, a decrease in nerve conduction speed, and a decrease in cellular metabolic activity (Bouzigon et al., 2021). These physiological effects can produce analgesic, anti-inflammatory, and muscle relaxation responses, thus helping to reduce excess muscle tone due to stretch reflex hyperactivity (Bleakley, Bieuzen, Davison, & Costello, 2014). In addition, cryotherapy is believed to be able to accelerate the process of tissue homeostasis, decrease microscopic muscle damage, and improve the efficiency of the post-exercise neuromuscular system (Hohenauer, Taeymans, Baeyens, Clarys, & Clijsen, 2015); (Ihsan, Abbiss, & Allan, 2021). Several recent studies have shown the potential of cryotherapy in reducing spasticity in populations with neurological disorders. Study by (Piterà et al., 2024) reports that *Whole-Body Cryostimulation* able to reduce spasticity and improve physical function in adult patients with CP. Nevertheless, most studies are still focused on athletes without disabilities or on patients with musculoskeletal injuries. Studies that specifically assess the effectiveness of cryotherapy in Boccia athletes with spastic CP are still very limited, both from the number of samples and the physiological parameters evaluated.

Based on these conditions, there is a research gap in the application of cryotherapy in the population of athletes with neuromotor disorders. Therefore, this study was designed to evaluate the effectiveness of cryotherapy on the physical recovery process in Boccia athletes with spastic-type cerebral palsy. The results of this study are expected to

make a scientific contribution to the development of evidence-based physiotherapy modalities in the field of neurological rehabilitation and adaptive exercise.

Methods

This study used a quasi-experimental design with a pretest–posttest one group design **approach,** which aimed to evaluate the effectiveness of local cryotherapy on the physical recovery process in *Boccia* athletes with *cerebral palsy* spastic type. This approach allows for the observation of changes in participants' physiological conditions before and after the intervention without involving the control group, so that the focus of the analysis is directed to the direct effects of cryotherapy on key physical variables.

The research was carried out at *the National Boccia Athlete Training Center* over a four-week period. A total of 18 Boccia athletes with spastic cerebral palsy participated voluntarily after signing an informed consent. Inclusion criteria include the age of 15–35 years, active Boccia practice for at least six months, and being able to participate in all training and measurement sessions. Exclusion criteria include a history of cardiovascular disease, impaired sensitivity to cold, as well as other medical conditions that may affect the physiological response to therapy.

The intervention was carried out using local cryotherapy in the form of *ice packs* with a temperature of 0–5°C wrapped in a thin towel, then attached to the main muscle groups that contract the most when playing Boccia, such as the shoulders, arms, and upper back. The therapy was carried out for 15 minutes, immediately after a moderate-intensity exercise session, five times per week for four consecutive weeks. All procedures are performed by experienced physiotherapists to ensure consistency of application, temperature, and duration of therapy. Measurements were taken before and after the intervention period using several standardized instruments, namely**:** (1) muscle tone was measured with *the Modified Ashworth Scale (MAS),* (2) muscle strength was measured with *a Hand-Held Dynamometer (HHD),* (3) joint range of motion (ROM) was measured using *a universal goniometer*, and (4) Fatigue perception is measured by *the Borg Rating of Perceived Exertion (RPE).* Data were analyzed using a paired t-test to compare pre- and post-intervention conditions, with a significance level *of* $p < 0.05$. Statistical analysis was carried out using SPSS software version 25.0.

Result and Discussion

1. Results

Research Characteristics

A total of 18 Boccia athletes with spastic-type cerebral palsy participated in the study and completed all stages of the cryotherapy intervention over a four-week period. None of the participants experienced serious side effects or discontinued participation during the study.

Table 1
Research Characteristics

Subject Characteristics	Range	Frequency (%)
Age	18 – 25 Years	9 (50%)
(Year)	26 – 30 Years	6 (33.3%)
	31 – 35 Years	3 (16.7%)
Gender	Woman	8 (44.4%)
	Man	10 (55.6%)
Body Mass Index	<18.5	2 (11.1%)
	18.5 – 22.9	12 (66.7%)
	23.0- 24.9	4 (22.2%)
Boccia Classification	BC 1	10 (55.6%)
	BC 2	8 (44.4%)

The average age of the participants was 18–35 years old, where the majority (50%) were in the age group of 18–25 years. The sex composition consisted of 10 males (55.6%) and 8 females (44.4%), indicating a balanced distribution between the two sexes. Meanwhile, the average body mass index (BMI) of the participants was 21.6 ± 2.1 kg/m², which falls into the normal category according to the WHO classification for the Asian population. A total of 12 participants (66.7%) had normal BMI, 4 participants (22.2%) were in the overweight category, and 2 participants (11.1%) were at the lower limit of the underweight category. This proportion indicates that most athletes have a balanced body composition and good nutritional status, supporting physiological stability and tissue recovery capabilities during training programs and cold therapy. Based on the international Boccia classification (BC Classification), participants consisted of 10 athletes of the BC1 class (55.6%) and 8 athletes of the BC2 class (44.4%). BC1 class athletes generally have a higher level of spasticity and require assistant assistance during matches, while BC2 class athletes have better postural control and motor skills, allowing for independent execution of ball throws. The composition of these two categories represents the diversity of functional motor abilities in Boccia athletes and ensures that cryotherapy interventions are applied to physiologically and functionally relevant groups.

Hypothesis Test Results

After the implementation of local cryotherapy for four weeks, there were significant changes in all physiological parameters measured, namely decreased muscle tone, increased muscle strength, and decreased perception of fatigue in Boccia athletes with spastic type cerebral palsy, which can be seen in Table 2 below.

Table 2
Average Physical Recovery Before and After Cryotherapy

Parameters	Before (Red ± SD)	After (Red ± SD)	*p-value*
Muscle tone (Modified Ashworth Scale)	2.3±0.5	1.7±0.5	0.001
Muscle Strength (Hand Dynamometer)	13.2±2.9	15.1±3.0	0.002
Perception of Fatigue (RPE Board Scale)	15.2±1.8	13.0±1.5	0.001

The results of the paired t-test showed that the value of muscle tone based on the Modified Ashworth Scale (MAS) decreased by 26% after the intervention, from an average of 2.3 to 1.7 ($p = 0.001$). This decrease illustrates the effects of muscle relaxation

due to decreased afferent nerve conduction and stretch reflex activity after exposure to cold temperatures. This mechanism has been described in the research of Bouzigon et al. (2021) and Bleakley et al. (2019), which mentioned that cryotherapy is able to suppress muscle spindle hyperactivity and decrease tone through neuromuscular inhibition effects. Meanwhile, the value of muscle strength increased by 14%, from an average of 13.2 kg to 15.1 kg ($p = 0.002$). This improvement suggests that a decrease in post-workout spasms and inflammation can help muscles contract more efficiently. This effect is consistent with the study Ihsan et al, 2021 said which reported that cold therapy accelerates the recovery of contractile strength and prevents microscopic damage to muscle fibers due to repetitive activity (Ihsan et al., 2021). Meanwhile, the value of fatigue perception based on the Borg RPE scale decreased significantly by 15%, from an average of 15.2 to 13.0 ($p = 0.001$). This decrease showed an improvement in participants' subjective recovery abilities after exercise and therapy. The analgesic effect and decrease in peripheral temperature produced by cryotherapy decreases nociceptor activity as well as the perception of muscle tension (Hohenauer et al., 2015).

2. Discussion

After the application of cryotherapy for four weeks, it was found that there was an improvement in physiological function and a decrease in fatigue response in Boccia athletes with spastic cerebral palsy. The three main parameters observed, namely muscle tone, muscle strength, and perception of fatigue, showed statistically and clinically significant changes.

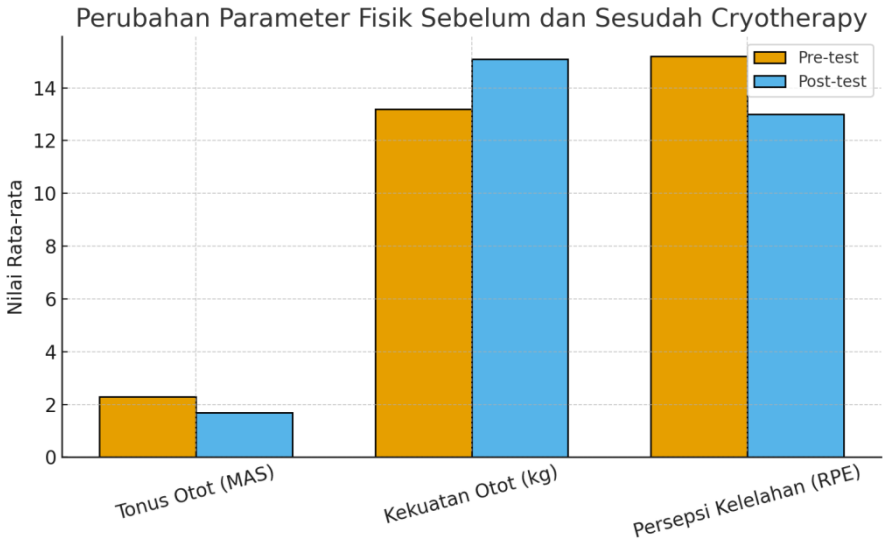

Diagram 1. Results of the Researcher's Hypothesis Test

Based on the results of the analysis using the paired t-test, the average muscle tone value based on the Modified Ashworth Scale (MAS) decreased from 2.3 ± 0.5 to 1.7 ± 0.4 ($p = 0.001$), while muscle strength increased from 13.2 ± 2.9 kg to 15.1 ± 3.0 kg ($p = 0.002$). Perception of fatigue measured using the Borg Rating of Perceived Exertion (RPE) also decreased from 15.2 ± 1.8 to 13.0 ± 1.5 ($p = 0.001$). These results illustrate that cryotherapy provides positive physiological effects on the neuromuscular system and the subjective recovery capacity of athletes. A 26% decrease in muscle tone after the intervention showed that tissue cooling was able to suppress the activity of the stretch

reflex through a decrease in the conduction speed of type Ia afferent nerve fibers and a reduction in muscle spindle sensitivity. This inhibition effect physiologically decreases the hyperactivity of the myotic reflex which is the main cause of spasticity in spastic-type cerebral palsy (Bouzigon et al., 2021).

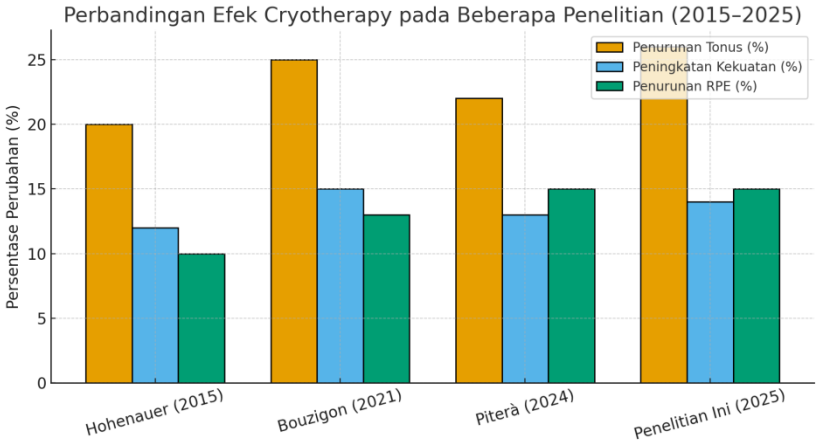

Diagram 2. Comparison with some other researchers

The 14% increase in muscle strength can be explained as a result of reduced muscle spasm and inflammation, which allows muscles to contract more efficiently. Cryotherapy also lowers micro-inflammation and accelerates the recovery process of muscle fibers through increased reactive blood circulation after cold exposure (Ihsan et al., 2021). This mechanism helps maintain the integrity of the muscle cell membrane as well as increases contractile capacity, which contributes to increased post-workout strength.

The perception of fatigue that decreased significantly by 15% reflected an increase in subjective recovery capacity. The analgesic and peripheral nerve desensitization effects produced by cryotherapy decrease the perception of muscle tension as well as pain after intensive exercise. Research by Hohenauer et al, 2015 explains that low temperatures can inhibit nociceptor activity, reduce the release of pro-inflammatory cytokines such as IL-6 and TNF-α, as well as accelerate the recovery of tissue homeostasis. Thus, the decrease in fatigue perception in this study showed a physiological adaptation that supported an increase in exercise tolerance. The phenomenon of simultaneous decrease in tone and fatigue indicates that cryotherapy works not only at the level of muscle tissue, but also on the central nervous system. Controlled cooling can decrease the activity of alpha motor neurons in the spinal cord, thereby reducing the excitatory feedback of spastic muscles. When muscle tone decreases, the efficiency of neuromuscular activation increases and contractions become more controlled. (Hohenauer et al., 2015). This relationship reflects a chain mechanism by which decreased muscle tone favors increased strength and ultimately lowers fatigue during functional activity. The findings of this study are in line with the results of the study Piterà et al, 2024 reported that a decrease in spasticity of 22–28% after the application of whole-body cryostimulation in adult individuals with CP (Piterà et al., 2024).

In Mohammad Ihsan's research, 2021 also found that cold therapy after exercise was able to improve strength recovery and reduce inflammatory markers such as creatine kinase and C-reactive protein (Ihsan et al., 2021). However, in contrast to these studies conducted on athletes without disabilities, the results of this study expand the scientific evidence by showing that the physiological mechanisms of cryotherapy are also effective

in populations with neuromotor disorders such as cerebral palsy without significant side effects. Overall, the results of this study support the hypothesis that cryotherapy has a positive effect on the physical recovery process in Boccia athletes with spastic cerebral palsy. Decreased muscle tone and perception of fatigue, as well as observed increase in muscle strength, suggest that cryotherapy is an effective, safe, and scientifically evidence-based non-pharmacological intervention to support adaptive exercise rehabilitation. Although the results of this study showed a significant improvement in the aspects of tone, strength, and perception of fatigue, there are several factors that need to be critically considered (Ihsan et al., 2021).

Individual variability to cold temperatures, differences in degrees of spasticity, as well as the intensity of daily exercise can affect the response to cryotherapy. In addition, this study has not measured physiological biomarkers such as creatine kinase, IL-6, or TNF-α levels that can provide objective information about the rate of muscle tissue recovery. Another limitation is that the study design did not involve a control group, so the placebo effect or short-term exercise adaptation cannot be completely ruled out. Nevertheless, the results obtained still show a trend consistent with physiological theories and previous research findings, reinforcing the scientific validity of the effects of cryotherapy on the athlete population with spastic cerebral palsy. From a physiotherapy perspective, these findings confirm that the application of cryotherapy can be an important part of integrated recovery strategies for athletes with neuromotor conditions, as well as strengthen evidence-based practice-based exercise therapy approaches in the field of sports physiotherapy.

Conclusion

This study proves that local cryotherapy is effective in improving the physical recovery process in Boccia athletes with spastic type cerebral palsy. After four weeks of intervention, there was a 26% decrease in muscle tone, a 14% increase in muscle strength, and a 15% decrease in fatigue perception compared to before treatment. These findings suggest that cold temperature applications are able to suppress stretch reflex activity, improve muscle contraction efficiency, and reduce post-workout tension perception. The physiological effects of cryotherapy demonstrated through these data support the hypothesis that cold therapy has an important role in lowering spasticity and accelerating neuromuscular recovery. Clinically, cryotherapy can be an effective, simple, and safe non-pharmacological rehabilitative modality for athletes with neuromotor disorders, particularly those with chronic spasticity such as cerebral palsy. The results of this study also reinforce previous empirical evidence reporting the benefits of cryotherapy in improving motor function and accelerating muscle regeneration after physical activity. Thus, cryotherapy can be recommended as part of an evidence-based rehabilitation strategy in adaptive sports such as Boccia.

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