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Physiotherapy in the rehabilitation of paediatric burns: a literature review

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Abstract:

The aim of the study was to review the latest literature in order to identify physiotherapeutic methods used in the rehabilitation of children who had suffered burns and to determine those which are most effective. Consequently, the PubMed database was searched and 46 works on different methods of rehabilitation used in the treatment of burns in children were analysed. Manual interventions such as scar massage or myofascial manual lymphatic drainage have a positive effect on scar quality. Physical interventions based on the exposure to light offer an effective method to improve scar cosmesis. The use of splints can be considered to prevent contractures. Resistance and aerobic training which increase muscle strength and physical capacity contribute to the recovery of pre-burn fitness. Yoga is also a good method of exercising. Virtual reality opens up opportunities to diversify regular physical exercise. Neither hypnosis nor music therapy have been confirmed to be effective in pain reduction in children.

Keywords: burns, scars, hypertrophic scars, keloids, children

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Introduction

Burns is one of the most traumatic and serious injuries among children. According to the newest WHO report published in 2008, the number of fatal burns in 2004 alone in children and young people under twenty years of age was nearly 96,000, with the highest percentage reported among infants [1]. Most burns occur in family homes in the afternoon and in the evening, under the care of parents. The prevalence is higher in boys than girls (in all age groups). The children admitted to hospital due to burns were most often those aged 1-2 years. The injuries usually included limbs and the chest and the most common cause was hot water. Burns up to 5% TBSA represented the majority of cases. The vast majority of patients underwent conservative treatment, with hospitalization for up to 3 days [2].

The aim of this review was to assess the effectiveness of various rehabilitation methods used in the treatment of children and young people who have suffered burns. What methods were used to support burn treatment in children? Which methods can improve the rehabilitation process?

Material and Methods

The PubMed database was employed to review the literature. The phrase "treating burns in children" was used as a keyword when searching the database. Articles in journals such as meta-analyses, literature reviews, randomized and non-randomized controlled trials, and case studies were taken into consideration. Only the publications which described post -burn rehabilitation in children aged 0 - 18 were included in the review. The review used the methods available in physiotherapy: physical therapy based on the exposure to external stimuli, kinesiotherapy and massage. Furthermore, the study was based on the use of new technologies and methods that are not included in the canon of standard treatment such as hypnosis or music therapy. Another inclusion criterion was the year of publication, using articles published after 2014, written only in English and with full text availability. Publications that included studies on adults and studies on animals were rejected. The next rejection criterion was the type of intervention i.e. surgical procedures such as skin grafts, pharmacological treatment and the use of silicone plasters. After the preliminary analysis, 60 articles were evaluated by means of the analysis of abstracts, with 46 articles finally included in the study.

Furthermore, the studies were classified according to Cochrane levels of evidence [Fig. 1]. The strength of the evidence was divided into 2 levels. A high level of evidence was provided by meta-analyses, literature reviews and randomized controlled trials included in the study. A low level of evidence was found in non-randomised trials and individual case studies [3].

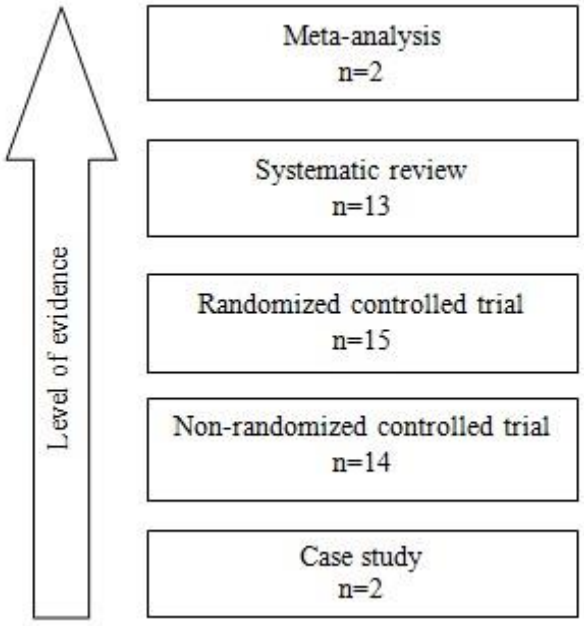

Figure 1. Quality of evidence according to Cochrane

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Results

The study analysed 46 articles about the rehabilitation of children following burns. Sixteen of them came from the United States of America, 5 from Australia, 4 from Egypt, 3 from Brazil, 2 from South Africa, 2 from Canada, 2 from Great Britain, 2 from India, 2 from the Netherlands and 1 each from Lebanon, the Czech Republic, Switzerland, Austria, Turkey, Kosovo and Poland. All articles were published after 2014. One of them was published in 2019, 16 in 2018, 13 in 2017, 5 in 2016, 4 in 2015 and 7 articles in 2014.

Considering the quality of evidence, 2 publications were classified as meta-analyses, 15 publications as systematic reviews, 15 of which were randomized controlled trials. Thirty-one publications had a high quality of evidence. The remaining 15 articles were of poor quality of evidence, including 16 non-randomized controlled trials and 2 case studies.

The publications examined various variables such as: pain, itch, scar quality, range of movement, muscle strength, lean body mass, physical capacity and anxiety level [Tab. 1]. The level of pain was assessed in 7 articles, using, among others, a visual analogue or numeric pain scales. The itch was examined in 3 publications based on the Visual Analogue Scale, the Itch Man Scale and the Toronto Scale. Sixteen publications used the evaluation of scar quality, using, among others, the Vancouver Scale and ultrasound examinations. The evaluation of the range of movement after rehabilitation appeared in 9 articles. The Biodex system was one of the ways to evaluate muscle strength following the therapies, which was verified in 9 publications. Seven publications measured aerobic capacity by determining VO_{2max}. The level of anxiety was examined in 7 publications.

The publications described various methods of rehabilitation of children who suffered burns. Fourteen of them analysed manual interventions such as massage or pressure therapy and assistance in the form of orthopaedic supplies [Tab. 2]. Physical therapy methods based on the exposure to external stimuli were described in 13 articles (most of them concerned laser and light therapies). Twenty-one publications examined the effects of different types of training on the effectiveness of rehabilitation. The other 3 articles were classified as 'Other', including hypnosis and music therapy [Fig. 2].

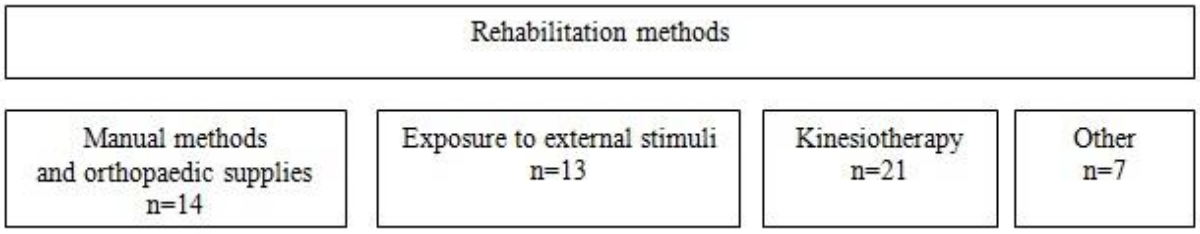

Figure 2. Physical therapy methods in treatment of burns in children

Furthermore, the publications on rehabilitation in case of hypertrophic scars (11 articles) and those describing the treatment of keloids (2 publications) were distinguished [Tab. 3].

Discussion

Rehabilitation of children who suffered various types of burns is of particular importance since the consequences of such injuries may persist from childhood to adult life. The aim of

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Table 1. Variables studied and methods used to measure them

Variable	**Measurement method**
Aerobic capacity [45]	Maximum heart rate
Aerobic capacity [9, 18, 32, 33, 35, 36, 45]	VO_{2max}
Anxiety [10]	Yoga Evaluation Questionnaire (YEQ)
Anxiety [39]	BSPAS Scale
Anxiety [42]	COMFORT behavioural scale
Anxiety [42]	Numeric Anxiety Rating Scale (NRSD)
Anxiety [7]	Observation of behaviour
Anxiety [8, 39 ,41]	Visual Analogue Scale (VAS)
Itch [4]	Itch Man Scale for Children
Itch [4, 26, 44]	Visual Analogue Scale (VAS)
Itch [44]	Toronto Pediatric Itch Scale
Lean body mass [6, 9, 16, 32, 35, 45]	DEXA system
Muscle strength [16]	3 - repetition maximum
Muscle strength [37]	Grip strength according to the American Society of Hand Therapists (ASHT)
Muscle strength [6, 9, 16, 18, 32, 35, 36, 45]	Biodex system
Pain [28]	Pain Observation Scale for Young Children (POCIS)
Pain [28]	COMFORT behavioural scale
Pain [28]	COMFORT-B behavioural scale
Pain [28, 39, 40]	FLACC Scale
Pain [30, 39]	Numeric Pain Rating Scale (NPRS)
Pain [4, 7, 8, 28, 39, 41]	Visual Analogue Scale (VAS)
Pain [40]	Faces Pain Scale
Range of motion [20]	Subjective assessment
Range of motion [29, 30]	3D motion analysis system
Range of motion [4, 23, 26, 30, 37, 39, 46]	Goniometer
Scar quality [1, 2, 24, 46]	USG
Scar quality [1, 2, 4, 11, 13, 14, 24, 25, 26, 27, 38 , 44, 46, 47, 48]	Vancouver Scar Scale (VSS)
Scar quality [1, 2, 46]	Doppler ultrasonography
Scar quality [24]	Physician Global Assessment (PGA)

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Table 1. Cont.

Variable	Measurement method
Scar quality [24]	Manchester Scar Scale (MSS)
Scar quality [24]	Stony Brook Scar Evaluation Scale (SBSES)
Scar quality [24, 26, 46]	Patient and Observer Scar Assessment Scale (POSAS)
Scar quality [8]	Subjective evaluation of an independent paediatric surgeon

Table 2. Procedures or groups of procedures

Authors	Procedures	Quality of scientific evidence
Alsharnoubi J et al., 2018 [16]	low-energy laser	high
Alsharnoubi J et al., 2018 [17]	low-energy laser	high
Atiyeh B, Janom HH, 2014 [4]	scar massage, pressure therapy	high
Ault P et al., 2018 [7]	scar massage	high
Brink Y et al., 2016 [31]	resistance exercises	high
Burns-Nader S et al., 2017 [48]	the use of new technologies	high
Chester SJ et al., 2018 [47]	hypnosis	high
Clayton RP et al., 2017 [34]	resistance exercises, fitness exercises	low
Conn AS et al., 2017 [49]	yoga exercises	high
Dodd H et al., 2017 [5]	scar massage, pressure therapy	high

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Table 2. Cont.

Authors	**Procedures**	**Quality of scientific evidence**
Edionwe J et al., 2016 [39]	vibration platform exercises	high
Elmelegy NG et al., 2018 [26]	electrophotobiomodulation	low
Elrashid NAA et al., 2018 [23]	orange polarized light	high
Flores O et al., 2018 [33]	resistance exercises, fitness exercises	high
Gittings PM et al., 2018 [32]	resistance exercises	high
Gokalp H, 2017 [18]	low-energy laser	low
Hardee JP et al., 2014 [29]	resistance exercises, fitness exercises	high
Jacobson K et al., 2017 [10]	use of stabilization splints	high
Lee JO et al., 2017 [35]	resistance exercises, fitness exercises	high
Liuzzi F et al., 2015 [12]	pressure therapy	high
Loskotová A et al., 2017 [9]	myofascial manual lymphatic drainage	low
Lozano EI et al., 2018 [40]	virtual reality exercises	high
Majid I et al., 2018 [19]	high-energy laser	low
Mamalis et al., 2014 [25]	high-energy laser, low-energy laser, pulsed light, LED therapy	high
Moiemen N et al., 2018 [13]	pressure therapy	low
Moufarrij S et al., 2014 [27]	hydrotherapy	high
Pardesi O et al., 2017 [43]	virtual reality exercises	high

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Table 2. Cont.

Authors	Procedures	Quality of scientific evidence
Parry I et al., 2014 [41]	virtual reality exercises	high
Parry I et al., 2015 [42]	virtual reality exercises	high
Peña R et al., 2016 [36]	resistance exercises, fitness exercises	high
Porter C et al., 2015 [30]	resistance exercises, fitness exercises	high
Rabello FB et al., 2014 [14]	pressure therapy	low
Rivas E et al., 2018 [28]	resistance exercises, fitness exercises	low
Rivas E et al., 2018 [38]	resistance exercises, fitness exercises	high
Rrecaj et al., 2015 [11]	use of stabilization splints, resistance exercises	low
Sarkar A et al., 2014 [24]	pulsed light	low
Scapin SQ et al., 2017 [45]	virtual reality exercises	low
Scapin SQ et al., 2018 [44]	virtual reality exercises	high
van der Heijden MJE et al., 2018 [46]	music therapy	high
van Dijk et al., 2018 [6]	scar massage	high
Wiseman J et al., 2019 [15]	pressure therapy	low
Wong BM et al., 2017 [20]	high-energy laser	low
Wurzer P et al., 2016 [37]	resistance exercises, fitness exercises	high
Żądkowski T et al., 2016 [22]	high-energy laser	low
Zhangab Y et al., 2017 [8]	passive stretching	high
Zuccaro J et al., 2017 [21]	low-energy laser, high-energy laser	high

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Table 3. Methods used in the rehabilitation of hypertrophic scars

Authors	Type of scar	Method
Atiyeh B et al., 2014 [4]	hypertrophic scar	massage, pressure therapy
Ault P et. al., 2018 [7]	hypertrophic scar	massage
Dodd H et al., 2017 [5]	hypertrophic scar	massage, pressure therapy
Elmelegy NG et al., 2018 [26]	hypertrophic scar	electrophotobiomodulation
Gokalp H, 2017 [18]	keloid	low-energy laser
Majid I et al., 2018 [19]	hypertrophic scar	high-energy laser
Mamalis et al., 2014 [25]	keloid	high-energy laser, low-energy laser, pulsed light, LED therapy
Moiemen N et al., 2018 [13]	hypertrophic scar	pressure therapy
Wiseman J et al., 2019 [15]	hypertrophic scar	pressure therapy
Wong BM et al., 2017 [20]	hypertrophic scar	high-energy laser
Żądkowski T et al., 2016 [22]	hypertrophic scar	high-energy laser
Zhangab Y et al., 2017 [8]	hypertrophic scar	passive stretching
Zuccaro J et al., 2017 [21]	hypertrophic scar	low-energy laser, high-energy laser

the rehabilitation is to improve the quality of life, optimize the treatment process, improve function and reduce pain.[4]

Manual methods and orthopaedic supplies

Massage is a standard therapy in centres specializing in the rehabilitation and treatment of scars. The indications for its use vary depending on the location of the burn and the type of scar. Although different techniques can be used, there are no clear guidelines, whereas the use of massage is based on experience rather than scientific evidence. The study evaluating the effects of massage on hypertrophic scars administered for 3 months did not show a significant effect on scar quality [5]. A study by van Dijk et al. [6], aimed to examine the effects of massage on stress reduction, demonstrated the ineffectiveness of this therapy with or without the use of essential oils in reducing stress and heart rate. Another review found that massage can affect scar quality, pain, itching and depressions in the case of treating hypertrophic scars. However, the authors concluded that the quality of evidence was low and further research was needed [7].

Stretching is the most commonly used method in the treatment of scars. The authors of an analysis aimed to determine its efficacy for scars drew cautious conclusions about the potential use of this method in the rehabilitation process [8].

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Myofascial manual lymphatic drainage is a relatively new method that seems to be effective as it improves microcirculation thus reducing scarring. It consists in the application of lymphatic drainage in the form of slight pressure applied to scar tissue on which trigger points were developed. Early introduction of this method contributes to faster scar healing and reduces the risk of scar hypertrophy [9].

There are no clear guidelines for the use of splints to prevent contractures, but evidence supports early use of orthoses [10]. The research demonstrated that the use of splints alone may be more effective in contracture reversal than other methods at later stages of rehabilitation [5]. Poor quality evidence indicates that the use of orthoses combined with physiotherapy in the form of scar mobilization, use of specific treatment positions and strengthening exercises in case of hand burns yields good effects in the early stages of rehabilitation [11].

The literature still questions the efficacy of pressure garment in the treatment of burns. Nevertheless, it is currently the standard of treatment by its non-invasiveness [5]. A review published in the United Kingdom [12] found that scars healed faster in children who wore pressure garment. Other researchers from the UK failed to draw conclusions about the advantage of the use of pressure therapy over its absence [13]. The amount of effective pressure generated by specific pieces of pressure garment also remains unknown and controversial. Problems with the decreasing pressure of the garment over time and problems with respecting recommendations by patients using the clothing are other factors that make this problem complex [14]. However, a consensus was established that determines the best pressure range at 15-25 mmHg to stimulate tissue healing [15].

Rehabilitation following burns using the exposure to external stimuli

Alsharnoubi et al. [16] conducted a 12-week analysis aimed to determine the effectiveness of the low-energy laser as a tool to improve scar quality in children who suffered burns. The results showed a significant reduction in scar thickness and an overall improvement in scar quality. Another analysis by the same author found that laser therapy has an inhibitory effect on scar growth, inhibits fibroblast viability and causes an increase in apoptosis compared to the unexposed body areas [17]. An analysis from 2017 [18] shows that the use of a high-energy laser helps reduce scars. Fractional CO_2 laser treatment combined with steroids may provide therapeutic benefits in the form of the improvement in post-burn scar quality in children, thus reducing the Vancouver Scale score [19,20]. Furthermore, the analysis presented by Zucarro et al. [21], which was supposed to assess the effectiveness of laser therapy in the treatment of hypertrophic post-burn scars, demonstrated improvements in 11 out of 12 studies. However, all studies were of the low quality of evidence and at risk of bias. Therefore, there is not enough evidence to confirm the effectiveness of laser therapy. Żądkowski et al. [22] showed in their study that the use of CO_2 laser improves the appearance and morphology of scars assessed using the Vancouver Scale. Orange polarized light may have a positive effect on scar quality improvement [23]. Another publication evaluating the effectiveness of pulsed light also drew positive conclusions about the efficacy of its use to reduce the scar, improve its vascularization and reduce thickness [24]. Mammalis et al. [25] reviewed the literature on light and laser therapy for keloids and concluded that both therapies may produce positive results. Both laser and other light-based methods can result in improved quality and reduced

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keloid recurrence. Another physical treatment based on a combination of pulsed light and high-frequency current termed photobiomodulation significantly reduced the Vancouver scale score after this treatment in children who suffered facial burns. Moreover, the study participants did not report any side effects, so it is a safe procedure, but also more economical than other treatment methods [26].

Rehabilitation after a burn using hydrotherapy can bring many benefits to patients who suffered burns. The therapy uses special mineral-enriched hot spring water and water streams with different water pressure to combat hypertrophy, inflammatory reaction symptoms and abnormal scar pigmentation [27].

Physical exercises

Experiencing extensive body burns results in immobilization of children in bed and, consequently, a decrease in both muscle mass and strength [4]. Currently, there are no clear guidelines for introducing physical exercise in children after burns. However, studies have suggested that physical capacity can be improved by aerobic training performed at five metabolic equivalents for at least 3 days a week and 150 minutes a week and by resistance training performed at a volume-based load (repetitions × sets × weight) of 131 kg for the upper body and 275 kg for the lower body for 2 days a week [28]. Immediate implementation of the resistance training programs seems to be suitable for the recovery of muscle mass and strength loss after the burn [29,30]. Although an analysis from South Africa [31], which evaluated the effects of strength training on the increase in lean muscle mass and strength in children who experienced more than 30% body burns revealed that there is currently no evidence of additional benefits of strength training for children after burns. However, no deterioration in strength and muscle mass was observed and therefore it is worth considering the implementation of individualised exercise programs. In the review presented by Gittings et al. [32] the authors argued that resistance exercises do not affect lean body mass but can increase muscle strength, but it was found that the evidence from which they drew the conclusions was of poor quality. Furthermore, an analysis carried out by Flores [33] showed that physical exercise has a beneficial effect on the physical and mental status of patients, but the evidence is limited and therefore more and better research is needed. In another study, the authors decided to compare the 6-week and 12-week exercise protocols. It was found that already 6 weeks after the beginning of rehabilitation, muscle strength, lean body mass and physical capacity measured with VO_{2max} increased. In the group that underwent 12-week rehabilitation, these results were significantly higher [34]. A retrospective review was conducted on the collected data of children who suffered burns and additionally underwent surgeries to remove contractures in the shoulder, elbow or wrist. An about 60% decrease in the frequency of re-surgeries was found in patients who used physical exercises, and therefore the implementation of exercises may reduce surgical interventions in such children [35]. Patient (7-18 years old) with burns ≥ 30% of the total body surface area (TBSA) were randomly assigned to participate in the COMBEX program or outpatient exercise program (EX) at the hospital. Both programs were started after discharge from the hospital and involved 12 weeks of progressive resistance and aerobic exercises. COMBEX was conducted in fitness centres near the patients' homes. Both EX and COMBEX effectively improved lean body mass, strength and cardiopulmonary capacity in severely burnt children [36]. The analysis from 2015 [11] which concerned hand

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burns revealed that in combination with other scar treatment methods, resistance exercises play an important role in rehabilitation and should be introduced as soon as possible. Although it may seem that physical exercise can improve strength, help regain muscle mass and increase physical capacity, there is not enough data to determine whether the effects of such rehabilitation will last for a long time [37]. Nevertheless, this rehabilitation model causes children to be able to match the level of activity of their peers who have not suffered burns after discharge from the hospital [38]. Training on a vibration platform may increase bone density with simultaneous improvements in strength and muscle mass [39]. A very interesting alternative for training is the use of modern technologies. One of such solutions is Xbox Kinect ™. In children who participated in rehabilitation using this device, the range of motion was improved and pain and stress were reduced due to the diverted attention caused by games [40]. The next analysis compared Xbox Kinect ™ with Playstation 3 Move ™. An increase in the range of joint mobility was also observed, sufficient for a child to be able to perform everyday activities independently [41]. Standard rehabilitation was compared with rehabilitation using interactive devices. It turned out that the rehabilitation improved the range of movement in both cases. However, the observation showed that the group involved in rehabilitation through interactive games had the best results in the first 3 weeks whereas in the group with standard rehabilitation, this occurred after 3 months. Furthermore, the group using interactive games complained less about pain [42]. Exercises based on virtual reality increase children's fun during rehabilitation and reduce stress and pain associated with changing clothes or burn dressings [43,44,45].

Other methods

Music therapy proved to be ineffective in reducing pain and stress in children. However, children older than 5 years of age reported significantly reduced stress following the therapy [46]. Another method that has been analysed is hypnosis. Chester et al. [47] attempted to find how hypnotherapy reduces pain and improves tissue healing. The children were divided into 2 groups: the first one received standard therapy, while the other, apart from the therapy, was also undergoing hypnosis. No differences were observed between these groups. Electronic devices such as tablets can also improve rehabilitation effects in children, reduce stress levels and divert attention from pain [48]. There is more and more evidence for the effectiveness of using virtual reality as an element that diversifies rehabilitation [43]. Yoga exercises can also reduce stress related to injury, and yoga can effectively complement both long-term and short-term burn treatment [49].

Physiotherapy offers a number of more or less effective rehabilitation methods. The most important thing is to start rehabilitation quickly in order to avoid complications. The therapeutic manual interventions such as scar stretching or massaging them can positively affect scar quality. The use of myofascial manual lymphatic drainage in the early stages of rehabilitation may accelerate wound healing and reduce the risk of scar hypertrophy. The use of splints can prevent contractures. Although there is no evidence of the effectiveness of the use of pressure garment, it was empirically proven in patients with burns. However, there is much evidence to support the use of laser and light therapy to improve scar cosmesis, in both hypertrophic scars and keloids. Hydrotherapy also seems to work well as a physical therapy method used to treat scars. Although some authors have failed to prove the effectiveness of

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physical exercise to increase strength and muscle mass, it appears that such training brings benefits and accelerates recovery. Virtual reality games can be successfully used in rehabilitation in order to improve both mental and physical health of patients. Unfortunately, music therapy and hypnosis did not show rehabilitation effects. Yoga exercises, on the other hand, perfectly complement the healing process in children. However, good quality randomized trials and meta-analyses are still needed to determine with certainty which physiotherapeutic methods are most effective in the rehabilitation of children after burns and to standardize the algorithm of rehabilitation following such injuries.

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