



Original article



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Impact of guidance and telemonitoring on foot flexibility due to postural congenital clubfoot in the first month of life: a longitudinal descriptive study

Impacto da orientação e do telemonitoramento na flexibilidade dos pés devido ao pé torto congênito postural no primeiro mês de vida: um estudo descritivo longitudinal

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ABSTRACT | INTRODUCTION: Early intervention is essential for proper foot growth in postural congenital clubfoot (PCC), but little is known about its contribution to this deformity when subjects are evaluated through telemonitoring. **OBJECTIVE:** This study aimed to monitor the foot's flexibility of newborns diagnosed with PCC by telemonitoring them during the first months of life. **METHODS:** A longitudinal descriptive study was carried out with a full-term newborns group diagnosed with PCC in at least one limb, presenting a grade $\geq 0,5$ on the Pirani score. Newborns with other malformations were excluded. They were assessed twice: before and 30 days after hospital discharge, and the foot flexibility classification by the Pirani score was provided. The telemonitoring occurred weekly between the assessments, and the parents were encouraged to mobilize their feet and maintain foot position using orthosis or taping. **RESULTS:** Thirteen newborns (eighteen feet) presenting PCC were included in this study; seven neonates discontinued the study due to absences from pre-scheduled evaluations, and six were telemonitored for 30 days. They were born at 39 weeks (± 1.18) and 3346.54 g (± 306.51). The majority of the newborns were female (69%), one was born vaginally, and eight (61%) had a family history of PCC. Pirani's score ranged from 1 to 3 in the initial assessment. After one month of telemonitoring, three feet progressed to 0, and four feet scored between 0.5 and 1. **CONCLUSION:** This study shows an important improvement in the foot's flexibility of newborns diagnosed with PCC evaluated through telemonitoring. Telemonitoring may be an additional resource for assisting newborns with PCC.

KEYWORDS: Newborn. Orthosis. Congenital Clubfoot. Telemonitoring.

RESUMO | INTRODUÇÃO: A intervenção precoce é essencial para o correto crescimento do pé torto congênito postural (PTC), mas pouco se sabe sobre sua contribuição para essa deformidade quando os pacientes são avaliados por meio de telemonitoramento. **OBJETIVO:** Este estudo teve como objetivo acompanhar, por telemonitoramento, a flexibilidade do pé de recém-nascidos com diagnóstico de PTC durante os primeiros meses de vida. **MÉTODOS:** Foi realizado um estudo descritivo longitudinal com recém-nascidos a termo, diagnosticados com PTC em pelo menos um pé, apresentando escore de Pirani $\geq 0,5$. Foram excluídos recém-nascidos com outras malformações. Os recém-nascidos foram avaliados nas primeiras horas de vida e 30 dias após a alta hospitalar. Durante este período os pais foram incentivados a mobilizar os pés diariamente e manter a posição por meio de órtese ou bandagem. O telemonitoramento ocorreu semanalmente, e a flexibilidade dos pés foi classificada pelo escore de Pirani. **RESULTADOS:** Foram incluídos neste estudo treze recém-nascidos (dezoito pés), sete descontinuaram o estudo por faltas nas tentativas de contato e seis foram telemonitorados por 30 dias. A maioria dos RN era do sexo feminino (69%), nasceram com 39 semanas ($\pm 1,18$) e 3.346,54g ($\pm 306,51$). Um nasceu de parto normal e oito (61%) tinham histórico familiar de PTC. Inicialmente, a pontuação de Pirani variou de 1 a 3. Após 30 dias de telemonitoramento, três pés evoluíram para 0 e quatro pontuaram entre 0,5 e 1. **CONCLUSÃO:** Este estudo mostra uma melhora importante na flexibilidade do pé de recém-nascidos com diagnóstico de PTC, avaliados por telemonitoramento. O telemonitoramento pode ser um recurso adicional para assistência ao recém-nascido com PTC.

PALAVRAS-CHAVE: Recém-Nascidos. Órtese. Pé Torto Congênito. Telemonitoramento.

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1. Introduction

Congenital clubfoot, also known as *talipes varus*, is a multifactorial and idiopathic orthopedic deformity characterized by congenital dysplasia of musculoskeletal structures of the foot.^{1,2} It is the most common orthopedic abnormality in Brazilian children, with an incidence of 1:1000 live births and a male predominance in the proportion of 2:1.³ This condition can be classified as postural congenital clubfoot or teratogenic congenital clubfoot deformity, and it leads to changes in foot position (i.e., cavus and supine foot), including deformities such as varus of hindfoot, adduction, and inversion of midfoot and forefoot.⁴

Postural congenital clubfoot usually results from intrauterine malposition of the lower limb and is associated with a mild degree of deformation, absence of or benign stiffness, and lack of hindfoot equinovarus.⁵ The deformity associated with postural congenital clubfoot is easily reduced by weight-bearing on the foot during gait acquisition.⁵ Furthermore, conservative treatment (i.e., casting or taping) showed good responses within a few weeks⁵ and did not require longitudinal follow-up.^{4,5}

Chaweerat et al.⁵ verified that the spontaneous recovery rate might be high in newborns with postural congenital clubfoot, not requiring therapeutic intervention. However, they did not investigate stiffness or plantar arch development while reaching motor milestones related to gait acquisition.⁵ The promising potential for spontaneous remission in postural congenital clubfoot may be related to malleability and good elasticity of ligaments, joint capsules, and tendons of newborns and should be assessed early.¹⁻³

Considering that postural congenital clubfoot may negatively impact both foot/ankle growth and biomechanics, and that early intervention may contribute to better biomechanical outcomes, we hypothesize that telemonitoring could be a valuable resource to evaluate the flexibility of the feet of newborns diagnosed with postural congenital clubfoot during the first month of life.

Statistical data shows that almost 1 million children are living in areas where there is no access to children's health services.⁶ In Brazil, only 18% of children with developmental delays are identified at 3 years of age and, when they have milder forms of impairment, they are identified on average at 6 years of age. The Pediatric Society of Rio Grande do Norte, one of the northeastern Brazilian states, indicates that almost 85% of child health specialists reside in the capital and that only 15 of the 167 municipalities (8.9%) have pediatricians who live there. This study aims to monitor the foot's flexibility of newborns diagnosed with postural congenital clubfoot by telemonitoring them during their first months of life.

2. Methods

This longitudinal descriptive study was carried out with newborns delivered at the university hospital, from Northeastern Brazil between January and April 2020. The maternity is part of a hospital complex of the Federal University of Rio Grande do Norte, has 51 beds (10 in the neonatal unit), and is a reference in women's health. The public served is characterized as belonging to economic class D/E.⁷

2.1. Eligibility criteria

Full-term newborns diagnosed with postural congenital clubfoot in at least one limb, presenting grade > 0 on the Pirani score, and who started passive mobilization in the first 72 hours of life were included. Newborns with congenital malformations of another nature (e.g., neurological, traumatic, or degenerative) were excluded and referred to follow-up with a pediatric orthopedist.

The Pirani score classifies six clinical signs of contractures that define congenital clubfoot, with three items observed in the hindfoot regions and three in the midfoot. Each sign is scored from 0 to 1, of which 0 is without abnormalities, 0.5 is with moderate abnormality, and 1 is with severe abnormality. The total score ranges from 0 to 6; the higher score represents the more severe abnormality.⁸

2.2. Telemonitoring

During the 3-day inpatient period following birth, parents received instructions on telemonitoring, training in assessing anthropometric measurements, and guidance on performing the mobilization protocol at home. These activities were all conducted under the supervision of the same experienced physiotherapist, who possessed over 20 years of experience in neonatal care. Newborns were followed up weekly by telephone and reassessed after 30 days in the neonatal follow-up clinic.

Telemonitoring was pre-scheduled via text messages sent to participants' smartphones, and it was conducted using a dedicated smartphone application for instant messages and voice calls. All telemonitoring sessions were consistently overseen by the same physiotherapist (NSOH), who had received specialized training in telehealth assistance prior to the commencement of the study. The telemonitoring proposal was to ensure that all newborns received the mobilization protocol by the parents/guardians and maintained the correct foot position using the orthosis or taping. A booklet with illustrative information concerning manipulations and exercise frequency was also provided.

2.3. Mobilization protocol

The mobilization protocol consisted of talocalcaneal joint mobilization (30 repetitions), manual traction of the talocalcaneal joint sustained for 5 seconds, and proprioceptive stimulation of the dorsolateral foot (30 repetitions) three times a day for a period of 30 days, performed by parents and/or guardians at home. This protocol was adapted from Freire Campos et al.³ and Su et al.⁹ and reorganized based on principles of the Maitland mobilization that preconize passive, rhythmic, and oscillatory movements.¹⁰ After mobilization, the foot maintained the correct posture using the orthosis or taping.⁴⁻¹¹ The measure for applying the bandage was based on the midsection of the newborn's leg up to the plantar arch, characterizing the anchors, with no traction being applied to these fixation points (Figure 1).

Figure 1. Mobilization of the foot with the correct posture using the orthosis (A) or taping (B)



Source: the authors (2020).

2.4. Anthropometric evaluation of the foot

Newborns were evaluated at hospital discharge and after 30 days, and foot flexibility was assessed using the Pirani score.¹² The following anthropometric data were assessed using a non-stretchable measuring tape: calf circumference (maximum calf circumference in perpendicular plane related to longitudinal line of calf), leg length (vertical distance between the perpendicular line of femoral acetabulum and calcaneus, with lower limb extended), and foot length (from tip of hallux to tip of calcaneus).^{13,14} Measurements were taken bilaterally, regardless of the deformity side. Skin integrity (i.e., hydration and possible tissue damage or pressure points) was also assessed during clinical inspection.

2.5. Statistical analysis

Descriptive data analysis was performed using Statistical Package for the Social Sciences (SPSS, IBM Corp, USA) software, version 20.0. Neonatal and gestational variables and anthropometric characteristics are presented as central tendency and dispersion measures in a frequency table. To analyze the Pirani score, an average of the values obtained in the initial and final evaluations was generated. These averages were then presented in a graph. The sample size was calculated (G* Power software, version 3.1.9.4) considering the difference between two dependent means (before and after telemonitoring) and the Pirani score before (5.1 ± 1.1) and after (3.7 ± 0.8) conservative treatment.¹² With Cohen's d effect size of 1.37, power of .80, and α error of .05, the minimal number of feet was estimated as five.

3. Results

From January to April 2020, the hospital performed 119 deliveries with gestational age ≥ 37 weeks. Thirteen newborns (eighteen feet) who presented postural congenital clubfoot were included in the study. Seven neonates (eleven feet) discontinued the study due to absences from pre-scheduled evaluations and lack of feedback from telephone contact attempts.

Six newborns included were admitted to the rooming-in unit. They were born at 39 weeks (± 1.18) and weighed 3346.54 g (± 306.51). Most newborns were female (69%), one was born vaginally, and eight (61%) had a family history of congenital clubfoot. The initial characteristics of newborns' feet are shown in Table 1.

Table 1. Characteristics of included newborns with postural alterations of the feet

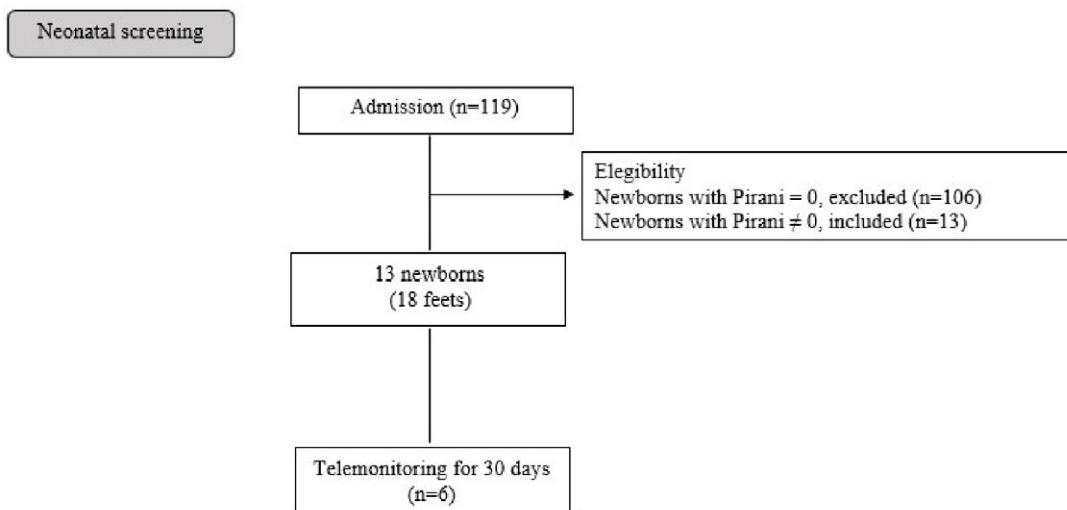
Initial characteristics of feet		N = 18 feet
Neonatal screening		N (%) or Mean (SD) right/left
Calf circumference (cm)		11.43 (± 0.89) / 11.39 (± 0.82)
Leg length (cm)		19.12 (± 1.16) / 19.1 (± 1.15)
Foot length (cm)		8.69 (± 0.5) / 8.89 (± 0.57)
Pirani classification		1.13 (± 0.65)
Laterality	Unilateral to the right	5 (27.5)
	Unilateral to the left	3 (17)
	Bilateral	10 (55.5)
Type	Varus	8 (44)
	Calcaneal varus	8 (44)
	Calcaneal valgus	1 (6)
	Varus equinus	1 (6)

SD: standard deviation; cm: centimeters.
Source: the authors (2020).

All mothers underwent prenatal care, and three (23%) had urinary tract infections. The results from ultrasounds performed during prenatal consultations did not show congenital limb malformations. As for childbirth care, two mothers (15%) used pharmacological interventions for pain relief and labor induction and were accompanied by their support network (partner or family).

Telemonitoring was applied for 30 days, being evaluated weekly, to six newborns (one with postural clubfoot bilaterally, seven feet) (Figure 2).

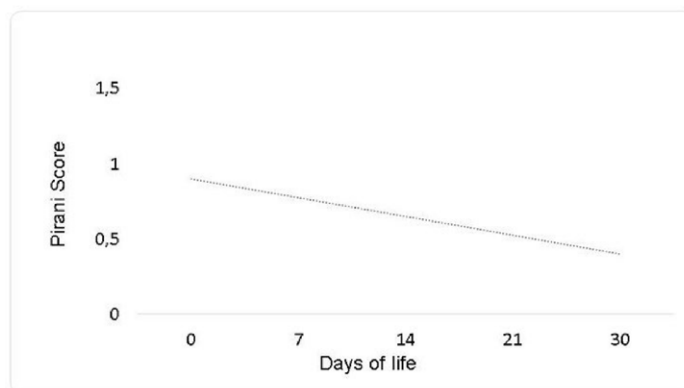
Figure 2. Study flowchart



Source: the authors (2020).

After one month of telemonitoring, three feet progressed to grade 0 on the Pirani score, and four scored between 0.5 and 1. Skin irritation was not reported, and newborns did not require treatment with percutaneous Achilles tenotomy. Figure 3 shows the evolution of foot flexibility observed during follow-up.

Figure 3. Evolution of foot flexibility according to Pirani's score, throughout 30 days of telemonitoring



Source: the authors (2020).

4. Discussion

This study telemonitored newborns with postural congenital clubfoot and their families during the first 30 days of life. At the end of the telemonitoring period, this research showed an important improvement in the foot's flexibility of newborns diagnosed with postural congenital clubfoot. Furthermore, telemonitoring proved to be a useful tool in monitoring the postural congenital clubfoot.

Few studies investigated foot growth of newborns with postural congenital clubfoot, mainly due to the high rate of spontaneous recovery of this condition.⁵ Postural congenital clubfoot usually develops later in the uterus, commonly associated with limited space.^{9,15} As a result, soft tissue and even bone changes are considered milder, with the potential for spontaneous remission.^{9,15,16} Aspects such as soft tissue contractures that cause shortening of tarsal ligaments and limited movement of subtalar joints may contribute to an imbalance between skeletal and muscular structures.¹⁷ These aspects justify our hypothesis and highlight the need for longitudinal surveillance of newborns diagnosed with postural congenital clubfoot.

Although postural congenital clubfoot does not always require therapeutic intervention, this study showed that telemonitoring was an important strategy for supporting the participation of families in the rehabilitation process. Telemonitoring may facilitate the overcoming of barriers experienced in face-to-face care (e.g., displacement to the health service)¹⁸ and contribute to regular communication between families and therapists, thus favoring engagement and adherence to treatment, strengthening parental empowerment to maintain foot mobilization in newborns.

Any telehealth intervention should be accessible, low-cost, and inclusive, and quality of care should be guided by communication strategies.^{6,19} Telehealth may follow up on clinical history, family context, foot appearance, and movement patterns under the guidance.^{19,20} Dimer et al.²¹ highlighted that training in communicative skills and prior face-to-face contact with health users are essential for greater adherence to telemonitoring, enhancing bonding and patient safety.

Despite orientation and facilitated communication, we observed a high rate of discontinuity to telemonitoring,

probably related to sociocultural and economic contexts in which families are inserted. Furthermore, social isolation due to COVID-19 might be linked to sociocultural conditions. The pandemic also exposed social inequalities, especially for families of children needing care.^{6,22} Families faced unemployment, financial difficulties, difficulty in health care access, and high rates of psychological suffering.^{6,22} The anxiety and fear potentially experienced by these families during the pandemic, organization of care at home, the newborn routine, and unavailability of the internet may have contributed to low adherence to telemonitoring.

Telemonitoring enabled the continuation of hospital-initiated conservative strategies. Conservative strategies are promising for treating postural congenital clubfoot.^{3,23,24} In addition, telemonitoring offers a unique opportunity for active parental engagement during treatment. Also serves as an essential alternative to encourage family participation and monitor their role in the care and rehabilitation of children with various health conditions, fostering a sense of support and bonding even when they are physically distant from healthcare services. The periodicity of telemonitoring, when alternated with face-to-face consultations, is also crucial for gaining a better understanding of family dynamics, enhancing the sense of security, and evaluating the effectiveness of long-term care.²⁵

This study exhibits some limitations. The suspension of face-to-face consultations due to the COVID-19 pandemic may have contributed to disruptions in telemonitoring, emphasizing the critical role of parental treatment adherence during rehabilitation. Effective healthcare systems should be meticulously designed to foster trust-based relationships and encourage active parental participation in adherence to treatment plans and collaboration with rehabilitation teams, as underscored by previous research.²⁵ To advance our understanding, there is a pressing need to promote the development of longitudinal and comparative studies involving a larger cohort of participants. Additionally, it should be noted that this phase of the study lacks both internal and external validation, though future research offers the opportunity to extrapolate and complete these validations with the results obtained.

5. Conclusion

This study showed an important improvement in the foot's flexibility of newborns diagnosed with postural congenital clubfoot. In addition, telemonitoring proved to be a useful tool in monitoring the postural congenital clubfoot, as it favored parental empowerment to maintain foot monitoring and enabled them to measure the evolution frequently through the Pirani score. Supporting parents' participation throughout telemonitoring may be an additional resource for assisting newborns with postural congenital clubfoot, especially for those children living in areas where there is no access to children's health services.

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Authors' contributions

Holanda NSO and Pereira SA were responsible for the idealization and design of the study. Holanda NSO was responsible for data collection and for the initial manuscript version. Azevedo IG, Sampaio SSS, Moura JR, Lima CDA and Holanda NSO were responsible for the statistical analysis. All authors reviewed and contributed to the final manuscript version.

Conflicts of interest

No financial, legal, or political conflicts involving third parties (government, private companies, and foundations, etc.) were declared for any aspect of the submitted work (including but not limited to grants and funding, advisory board participation, study design, manuscript preparation, statistical analysis, etc.).

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