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ASSOCIATION BETWEEN PATELLOFEMORAL PAIN AND GASTROCNEMIUS TIGHTNESS AMONG CLUBFOOT PATIENTS

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Abstract

Background: *Clubfoot or talipes equinovarus is a deformity of the leg, ankle, and foot. The hindfoot varus, the forefoot adduction, the equinus, and the enlarged midfoot arch (cavus) are the characteristics of clubfoot. Patellofemoral pain is mostly associated with restricted flexibility of lower limb muscles.*

Objective: *To investigate the association between patellofemoral pain and gastrocnemius tightness among clubfoot patients.*

Method: *It was a cross-sectional study. The duration of the study was 6 months. Non-probability convenient sampling technique was used. The sample size was 158.* ***Gastrocnemius tightness*** *was assessed by measuring dorsiflexion angle with extended knee using a goniometer and* ***patellofemoral pain (PFP)*** *was assessed by using the Kujala* ***Anterior Knee Pain Scale (AKPS).***

Results: *The mean age was 12.8 ± 3.74. The data showed that there were more males (66.5%) than females (33.5%). According to the findings, participants who had no gastrocnemius tightness (11°–20°) predominantly reported no knee pain, whereas those who had severe tightness (0°–5°) reported moderate to severe knee pain. Participants with mild to moderate tightness (6°–10°) also exhibited mild to severe pain. Statistically significant results were found by the Pearson Chi Square test (p = 0.000).*

Conclusion: *This study concluded that there is a significant association between patellofemoral pain and gastrocnemius tightness in clubfoot patients.*

INTRODUCTION

Clubfoot or talipes equinovarus (TEV) is a three-dimensional deformity of the leg, ankle, and foot. The hindfoot varus, the forefoot (metatarsus) adduction, the equinus, and the enlarged midfoot arch (cavus) are the characteristics of clubfoot (Basit and Khoshhal, 2018).

It is a common congenital abnormality with an average prevalence of about 1 per 1000 live births (Ansar et al., 2018). It predominates in males and 50% cases involve both sides (Maranho and Volpon, 2011). Out of all the birth defects, it is the seventh most prevalent musculoskeletal anomaly (Murtaza et al., 2020).

Clubfoot is typically classified into four types based on the underlying cause. The most frequently seen type, idiopathic clubfoot, has no known cause and is regarded as an isolated congenital defect (Cady et al., 2022). Positional

clubfoot results from incorrect fetal placement in the womb. It is flexible in nature making treatment easy. (Liu et al., 2016). Syndromic clubfoot demands more involved therapies and is linked to hereditary disorders like arthrogryposis or spina bifida. Furthermore, children with neurological illnesses such as cerebral palsy can develop neurogenic clubfoot (Rieger and Dobbs, 2022).

Congenital clubfoot is characterized by severe pathological changes associated with not only the foot, but the whole lower limb skeleton, pelvis and spine. Restrained movement of the ankle joint may lead to further atrophy of muscles, resulting in functional deficits as the deformity progresses (Nesterchuk et al., 2019). The other tissues (muscles, tendons and ligaments) also show serious changes in them (Mykhaylova and Grygus, 2013).

Clubfoot , a developmental deformity, is a complex hereditary trait that is influenced by genetic and environmental factors (Gurnett et al., 2023). Normally, fetal movement is restricted either due to low levels of amniotic fluid or by using harmful chemicals or due to infection during pregnancy (Rani and Kumari, 2017). Maternal smoking and a positive family history of clubfoot increase the likelihood twentyfold, suggesting a genetic disposition (Weymouth et al., 2015).

Clubfoot can be evaluated by using the Pirani classification system. It is used for determining the severity of the foot (López-Carrero et al., 2023). Clubfoot assessment can also be done using the DiMeglio classification (Canavese and Dimeglio, 2021). The severity of clubfoot is correlated with the stiffness of the ankle and subtalar joints; hence, greater stiffness indicates more severe clubfoot and may be linked to a higher risk of recurrence (Van der Steen et al., 2018).

Non-compliance with the foot abduction orthosis (FAO), soft tissue contractures, incomplete correction, unidentified neuromuscular causes can significantly raise the risk of relapse (Masrouha et al., 2021).

Ponseti approach is an efficient treatment of clubfoot that can minimize the need for major corrective surgery. But if nonoperative care fails, surgery is still an option, but it frequently results in long-term problems such chronic pain, diminished strength, and functional deficiencies in adolescents (Švehlík et al., 2017). However, because of the shortened Achilles tendon, the hindfoot equinus is the most challenging to repair of all the abnormalities. Therefore, Achilles tenotomy is used to treat this deformity and is a key component of Ponseti's approach (Rangasamy et al., 2022).

Localized pain of the anterior part of the knee is commonly referred to as patellofemoral pain (PFP) (Gaitonde et al., 2019). PFP is commonly attributed to patella-loading exercises including running, squatting, and climbing stairs (Petersen et al., 2017). Many functional abnormalities of the lower extremities may be involved in the multifactorial pathophysiology of PFPS (Petersen et al., 2014). Incorrect patella tracking in the femur's trochlea is probably caused by a combination of biomechanical variables as well as muscular and soft tissue abnormalities, which ultimately raises the stress at the patellofemoral joint (Hryvniak et al., 2014).

Limited ankle dorsiflexion (ADF) alters gait kinematics and is associated with many prevalent foot pathologies. Gastrocnemius tightness is the leading cause of reduced ADF (Baumbach et al., 2016). Tightness of the gastrocnemius muscle has further been associated with multiple musculoskeletal disorders, such as knee pain and back pain (Chan et al., 2019). The gastrocnemius acts antagonistically to the anterior cruciate ligament, so its contraction, especially at the end range of knee flexion, pulls additional tension on the ligament and possibly compresses the patellofemoral joint (Adouni et al., 2016).

Treated clubfoot patients might exhibit short, or tightened gastrocnemius muscle and Gastrocnemius tightness might reduce ankle dorsiflexion and may lead to altered gait mechanics that may increase loading to the patellofemoral joint during activity causing knee pain in clubfoot patients. To develop interventions that successfully consider the gastrocnemius flexibility and its relationship to patellofemoral pain in these individuals, it is crucial to fill this gap.

MATERIAL AND METHODS

A cross-sectional study design was used to find the association between patellofemoral pain and gastrocnemius tightness among clubfoot patients. The study was carried out in accordance with ethical standards after obtaining the approval from Research Ethics Committee (REC). Informed consent was obtained from all the participants meeting the inclusion criteria after they were explained about the goals, methods, risks, and advantages of the study. Participation was entirely voluntary. Participants were given the right to withdraw from the study at any moment. All information was properly kept, and data confidentiality was maintained.

The sample size was 158 which was calculated by Epitool. Non-probability convenient sampling technique was used. Individuals of both genders, aged between 8-20 years, who had previously received treatment for clubfoot (e.g. ponseti method or tenotomy) were included in this study. Exclusion criteria involved history of any knee surgery, any acute knee injury (e.g. history of knee or ankle fracture, ligament injuries), medical conditions affecting knee (e.g. osteoarthritis, rheumatoid arthritis, Osgood Schlatter disease) and lastly any congenital or neurological disorders (e.g. cerebral palsy, spina bifida).

A Goniometer and Kujala Anterior Knee Pain Scale (AKPS) served as the study's assessment tools. Both tools have high validity and test-retest reliability. **Gastrocnemius tightness** was assessed by measuring dorsiflexion angle with an extended knee by a goniometer. A reduced dorsiflexion angle was a sign of gastrocnemius tightness. Then **patellofemoral pain (PFP)** was assessed by using the **Anterior Knee Pain Scale (AKPS).** Participants answered a standardized questionnaire. The total score was calculated where lower scores denoted more severe PFP. For statistical analysis, all data were systematically recorded.

The SPSS software, version 25, was used to analyze the data. The mean and standard deviation were used to display the quantitative variables. Frequencies and percentages were used to display the qualitative factors. Pearson chi-square test was used to determine the association between patellofemoral pain and gastrocnemius tightness among clubfoot patients. A **p-value of <0.05** was considered statistically significant.

RESULTS

The mean age of participants was 12.8±3.74. The data indicated that there is an overrepresentation of males in the sample, with males (66.5%) substantially outnumbering females (33.5%).

Goniometer findings of dorsiflexion angle with an extended knee suggested that there is a significant percentage of the sample with varying degrees of gastrocnemius muscle tightness. 20.9% of participants indicated mild to moderate gastrocnemius muscle tightness, 36.7% reported moderate to severe tightness, and 42.4% reported no tightness at all.

Kujala Anterior knee pain scale (AKPS) scoring showed that 57% of individuals reported knee discomfort ranging from mild to severe, whilst the other 43% reported no pain at all. Of those with pain, 14.6% had severe pain, 32.9% experienced moderate pain and 9.5% had mild pain.

Crosstabulation between gastrocnemius muscle tightness and AKPS scoring showed that participants who had no tightness in their gastrocnemius muscles (11°–20°) predominantly reported no knee discomfort, whereas those who had severe tightness (0°–5°) reported moderate to severe knee pain. Participants with mild to moderate tightness (6°–10°) exhibited mild to severe pain.

Table 1: Crosstab between Gastrocnemius muscle tightness and AKPS scoring

		AKPS scoring			
		No knee Pain (90-100)	Mild pain (70-89)	Moderate pain (40-69)	Severe pain (0-39)
Gastrocnemius muscle tightness	No tightness (11°-20°)	50	5	10	2
	Mild to moderate tightness (6°-10°)	13	5	10	5
	Severe tightness (0°-5°)	5	5	32	16

Table 2: Chi-Square

Chi-Square test	Chi-Square value	Degree of freedom	Asymptotic significance (2-sided)
Pearson Chi-Square	61.372	6	0.000

The Pearson Chi-Square test indicated a strong and statistically significant association between gastrocnemius muscle tightness and patellofemoral pain (PFP) in clubfoot patients ($p = 0.000$). Patients with severe muscle tightness are more likely to experience higher levels of knee pain, while those with no tightness are more likely to report no pain.

DISCUSSION

Significant results were found in our study investigating the patellofemoral pain association with gastrocnemius muscle tightness among clubfoot patients. A study on patellofemoral pain syndrome (PFPS) by Sannasi et al. also found substantial connections between gastrocnemius tightness and knee pain in unilateral PFPS patients, which is consistent with the findings of our study. In addition, PFPS was also found to be strongly associated with tightness in the rectus femoris and iliotibial band (ITB). However, there were no noteworthy associations discovered with tightness in the hamstrings or quadratus lumborum (QL). These findings imply that a major contributing element to PFPS is tightness in the gastrocnemius. However, it is not the only risk factor (Sannasi et al., 2023). Additionally, a study by Moghadam and Keshavarz found that patients with patellofemoral pain syndrome (PFPS) had less flexibility in their gastrocnemius and soleus muscles. Their findings demonstrated that while there were no changes in quadriceps flexibility, PFPS patients had significantly decreased flexibility in these muscles when compared to healthy controls. These results support our findings. Their study, however, stresses the significance of treating muscle flexibility in the management of PFPS, whereas our study emphasizes the connection between gastrocnemius tightness and knee pain in clubfoot patients (Moghadam and Keshavarz, 2020). In line with our study, a study by Beyaert et al. on internal foot progression (inturning) in kids with treated clubfoot found that knee function can be

impacted by abnormal biomechanics. Inturning is common in 46% of clubfoot cases and has been associated with altered knee biomechanics that may lead to osteoarthritis and other long-term issues (Beyaert et al., 2003). A systematic review of Patellofemoral Pain Syndrome by Hall and Liu mirrors the findings of our study in presenting gastrocnemius tightness as a potential contributor to knee discomfort. The review also stated that PFPS is multifactorial, and that gastrocnemius trigger points, and tightness may aggravate symptoms (Hall and Liu, 2015). A case report by Dutton et al. was published on the rehabilitation of patellofemoral pain. The rehabilitation program outlined in this study focus on muscle flexibility and strengthening of the quadriceps and additional treatments of hip strengthening, patellar bracing, and gait modification. In line with our study, this research also highlighted the value of biomechanical factors and muscle tightness as major contributors to knee pain and thus they structured their treatment plan accordingly (Dutton et al., 2014). A study conducted by Waryasz and McDermott identified a few risk factors for patellofemoral pain, such as muscle weakness and aberrant patellar tracking, as well as tightness in the quadriceps, hamstrings, gastrocnemius, and iliotibial band. These results reflect the findings of our study (Waryasz and McDermott, 2008). Reduced ankle dorsiflexion was found by Hassan et al. as a contributing factor to PFPS. Given that one of the primary causes of reduced ankle dorsiflexion is gastrocnemius tightness, their results aligned with our findings (Hassan et al., 2022). The pilot study on Achilles tendon rupture (ATR) repair by Sun et al. and our research both demonstrated how knee problems were caused by dysfunction in the lower limbs. Our study discovered that gastrocnemius tightness in clubfoot patients contributed to patellofemoral pain, while the pilot study connected compensatory gait changes following tendon rupture repair to knee overuse injuries (Sun et al., 2020). The systematic review by Martinelli et al discovered insignificant correlations and moderate-quality studies investigating the relation between foot and ankle alignment (FAA) and patellofemoral pain syndrome (PFPS). In contrast, my research showed a strong association between clubfoot patients' knee pain and gastrocnemius tightness, indicating that muscle imbalances might affect PFPS more directly than just foot alignment (Martinelli et al., 2022). Our research and the study on knee muscle forces during walking and running in patients with patellofemoral pain and pain-free controls by Besier et al both demonstrated that altered muscle forces, whether brought on by tightness in the gastrocnemius or gender differences, increased knee joint stress and caused patellofemoral pain (Besier et al., 2009).

Despite the contributions, this study has some limitations. As cross-sectional study design was used so it is difficult to develop cause and effect link. It focused on gastrocnemius muscle tightness only without taking into account all the other possible factors that may cause patellofemoral pain in clubfoot patients. Future studies should go with the more comprehensive approach including all the other factors that may cause patellofemoral pain in clubfoot patients alongside gastrocnemius tightness. Using longitudinal study designs can help in finding whether severity in gastrocnemius tightness exacerbates pain over time and it will also prove beneficial in finding out cause and effect relationship between them.

CONCLUSION

The study concluded that there is a strong association between patellofemoral pain and gastrocnemius tightness in individuals with clubfoot history. The results imply that the onset and intensity of patellofemoral pain is significantly influenced by gastrocnemius tightness.

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