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GENERAL ORTHOPAEDICS

Foot function during gait and parental perceived outcome in older children with symptomatic club foot deformity

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Aims

To assess if older symptomatic children with club foot deformity differ in perceived disability and foot function during gait, depending on initial treatment with Ponseti or surgery, compared to a control group. Second aim was to investigate correlations between foot function during gait and perceived disability in this population.

Methods

In all, 73 children with idiopathic club foot were included: 31 children treated with the Ponseti method (mean age 8.3 years; 24 male; 20 bilaterally affected, 13 left and 18 right sides analyzed), and 42 treated with primary surgical correction (mean age 11.6 years; 28 male; 23 bilaterally affected, 18 left and 24 right sides analyzed). Foot function data was collected during walking gait and included Oxford Foot Model kinematics (Foot Profile Score and the range of movement and average position of each part of the foot) and plantar pressure (peak pressure in five areas of the foot). Oxford Ankle Foot Questionnaire, Disease Specific Index for club foot, Paediatric Quality of Life Inventory 4.0 were also collected. The gait data were compared between the two club foot groups and compared to control data. The gait data were also correlated with the data extracted from the questionnaires.

Results

Our findings suggest that symptomatic children with club foot deformity present with similar degrees of gait deviations and perceived disability regardless of whether they had previously been treated with the Ponseti Method or surgery. The presence of sagittal and coronal plane hindfoot deformity and coronal plane forefoot deformity were associated with higher levels of perceived disability, regardless of their initial treatment.

Conclusion

This is the first paper to compare outcomes between Ponseti and surgery in a symptomatic older club foot population seeking further treatment. It is also the first paper to correlate foot function during gait and perceived disability to establish a link between deformity and subjective outcomes

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Introduction

Children treated in infancy for idiopathic club foot can present with residual, relapsed, or over-corrected foot deformity. Follow-up at 11 years post initial surgery has shown 56% required at least one additional procedure at a mean of four years following the initial surgery.[1] In a prospective study comparing surgical versus Ponseti results, 38% of Ponseti and 30% of surgical subjects required additional procedures after three years of follow-up.[2] The results also showed the severity of recurrent deformity in the surgical group was higher than the Ponseti group; resulting in the surgery group requiring more corrective procedures to treat the persistent deformities.[2] More recently Hayes et al[3] reported a risk of over-correction following the Ponseti method of 12% after at least eight years of follow-up.

Due to a lack of evidence to guide clinical decision-making, current practices

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managing older children vary. How does a clinician decide who should receive additional surgical or conservative management, and who can be left untreated? There is a known association between the number of surgical interventions and level of perceived disability, however, the deformity may continue to progress if left untreated, causing disability into adulthood.[4,5]

To date, outcome studies in older children with club foot have focused on comparing different types of treatment using pedobarography,[6-9] lower limb kinematics and kinetics,[1,10-16] multi-segment foot kinematics,[16,17] and subjective questionnaires.[15-18] However, these have focused on children who are doing well. No published literature exists analyzing a symptomatic population of children previously treated for club foot deformity. We don't know if 'failed' Ponseti presents similarly to 'failed' surgery. In addition, no previous study has investigated the relationship between foot function (assessed by foot kinematics and plantar pressure) and patient reported outcome measures. Therefore our study hypotheses were:

1. There will be a difference in foot function during gait in older symptomatic children with club foot between those who have been previously treated by Ponseti compared to surgery; and that both will be different to a control group.
2. There will be a difference in perceived disability in older symptomatic children with club foot between those who have been previously treated by Ponseti compared to surgery.

If a correlation between foot function during gait and perceived disability could be established, it would give insight into the specific elements of foot deformity that are associated with poor subjective outcomes. This would enable treatment to target specific elements of the foot deformity, or else give evidence to reassure a family that no further treatment is indicated. Such correlations have not been established, and would need large numbers. Therefore, our third research question was more exploratory, with an aim to generate hypotheses for future studies:

3. What are the associations between foot function during gait and perceived disability in older symptomatic children with club foot who have been previously treated by Ponseti or surgery?

Methods

Subjects. In all, 73 children with idiopathic club foot were included (mean age 10.2 years, range 5 to 16 years; 51 male; 43 bilateral, 12 left, 18 right side affected). For bilateral subjects, the worst-affected foot as assessed by the Foot Profile Score[19] was included, resulting in 42 right and 31 left feet being analyzed. The sample included routine referrals- children referred to the clinical service for consideration of further management due to residual deformity, pain or reduced function. The gait laboratory is part of a tertiary hospital receiving referrals from multiple centres requiring this specialist service. The reasons for referral were to clarify residual foot abnormalities, advice on orthotic management, as well as potential surgical management. This indicates that a range of foot deformity were included in the sample. Inclusion criteria were subjects between the ages of five and 16 years of age with a confirmed structural idiopathic club foot deformity diagnosed at birth, and no other musculoskeletal or neurological diagnoses.

Of the 73 children, 31 were previously treated with the Ponseti method with the treatment starting within the first 4 months following birth. 83% of the Ponseti group had an Achilles tenotomy (26 children) and 32% subsequently had an anterior tibialis tendon transfer (ATTT) (10 children). One of the children, who did not undergo a tenotomy following the initial casting, had a limited Achilles tendon lengthening at two years old. The Ponseti group had a mean age 8.3 years (5 to 16 years); 24 male; 20 bilaterally affected, with a total of 13 left and 18 right sides analyzed.

The surgery group had 42 children treated with primary surgery before the age of 1 year old, following either strapping or below-knee casting. 24 children underwent posteromedial releases, 17 children had posterior releases, and 1 child had an Achilles tenotomy combined with a medial release. 19 of these children underwent subsequent surgery; 2 ATTT in isolation, 10 with an ATTT in combination with more extensive soft tissue release, capsular release, and tibial de-rotation osteotomies. The surgery group had a mean age 11.6 years (5 to 16 years); 28 male; 23 bilaterally affected, with a total of 18 left and 24 right sides analyzed.

Two control groups were used in the assessment of foot function selected from the gait laboratory's normal databases. The kinematic data control group consisted of 30 children, mean age 10.7 years (5 to 16 years). The plantar pressure control group consisted of 30 children, mean age 10.6 years (5 to 16 years). For both control groups, the participants included healthy children with no known diagnoses or orthopaedic conditions. In order to match the sex and age distribution of the club foot group, nine female and 21 male controls were selected for each group, using a stratified random sample (15 right and 15 left legs randomly selected).

Data collection

Foot function during gait. **Foot kinematic data.** All 73 children had multi-segment foot kinematic data collected using the Oxford Foot Model (OFM)[20] during level walking at self-selected speed using a 16 camera Vicon T-series system (Vicon Motion Systems Ltd, Oxford, UK) sampling at 100 Hz with 9.5 mm passive markers.

The Foot Profile Score (FPS) and 6 Foot Variable Scores were then calculated from the kinematic data of the OFM.[19]

Table I. The mean and range of the Foot Profile Score and the six Foot Variable Scores for all three groups (prior to log transformation). Welch ANOVA for all three groups and independent *t*-test (unequal variances assumed) between groups following log transformation (*= p < 0.05). A higher number indicates greater deformity.

	Mean and range			Welch ANOVA (p-values)	Independent t-tests (p-values)		
	Control n = 30	**Ponseti n = 31**	**Surgery n = 42**	**3 groups**	**Ponseti vs Control**	**Surgery vs Control**	**Ponseti vs Surgery**
Foot Profile Score (°)	4.8 (2.3 to 7.3)	8.3 (3.3 to 18.1)	9.3 (4.0 to 18.3)	< 0.001*	< 0.001*	< 0.001*	0.11
Hindfoot sagittal (°)	3.7 (2.1 to 7.9)	4.9 (2.0 to 10.9)	5.5 (2.5 to 21.5)	0.006*	0.03*	0.003*	0.50
Forefoot sagittal (°)	3.4 (2.0 to 8.8)	5.3 (1.7 to 12.0)	4.8 (2.1 to 17.1)	0.001*	0.001*	0.002*	0.47
Hindfoot coronal (°)	3.7 (1.2 to 8.7)	8.0 (2.2 to 19.4)	7.3 (1.7 to 18.3)	< 0.001*	< 0.001*	< 0.001*	0.49
Forefoot coronal (°)	4.9 (1.3 to 9.9)	6.9 (2.1 to 19.2)	9.1 (2.1 to 33.4)	0.001*	0.07	< 0.001*	0.07
Hindfoot transverse (°)	5.8 (2.5 to 15.5)	9.7 (2.7 to 20.8)	10.8 (3.4 to 23.7)	< 0.001*	0.001*	< 0.001*	0.39
Forefoot transverse (°)	5.0 (1.1 to 11.0)	9.1 (1.5 to 20.5)	10.6 (1.4 to 26.2)	0.001*	0.02*	< 0.001*	0.26

Since the FVS and FPS are absolute deviations from normal, we also calculated the average position of each segment during the gait cycle in each plane, which additionally gave the direction of deviation.

We also calculated the overall flexibility of each inter-segment joint by calculating the range of movement in each plane.

Plantar pressure data. Plantar pressure data were collected using an EMED-M pressure plate (Novel, Munich, Germany) sampling at 50 Hz. Total peak pressure and force-time integral were collected in 70 subjects. Due to technical difficulties, plantar pressure data from three subjects were not collected. Peak pressure in five areas of the plantar surface of the foot, defined by the kinematic markers: were measured in 59 subjects: medial and lateral hindfoot, midfoot, medial and lateral forefoot.[21] Due to technical difficulties we could not calculate pressure variables for sub-areas of the foot in 11 children, resulting in data from 28 Ponseti and 31 surgical subjects.

Perceived disability. Oxford Ankle Foot Questionnaire (OxAFQ)[22] was collected in all 73 subjects. The OxAFQ comprises three domain scores (physical, school and play, emotional). Roye's Disease Specific Index for club foot (DSI)[23] was collected in 38 subjects. This score measures the outcome of treatment of club foot and is composed of a satisfaction subscale and function subscale. In addition, the Paediatric Quality of Life Inventory 4.0 SF15 Generic Core Scales (PedsQL)[24] was collected in 34 subjects, comprising a psychosocial health summary score, physical health summary score and a total score.

Data analysis

Foot function during gait. The FPS, FVS, average position of each segment, flexibility of each segment, peak plantar pressure and force time integral data were compared between all three groups (the two club foot groups and the control group) using Welch's Analysis of Variance. Where significant differences were found, post hoc independent *t*-tests were used with unequal variances assumed. Log transformation was performed prior to the analysis for the FPS, FVS, flexibility score of each segment and plantar pressure data, because of marked positive skewness in these variables.

Perceived disability. An independent *t*-test was used to compare the means of the two club foot groups for each of the three subjective outcome measures with equal variances not assumed.

Association of foot function and perceived disability. For convenience in examining a large number of associations, Pearson Correlation Coefficients were used to explore the association between the independent variables (FPS, FVS, RoM of each foot joint in each plane, and plantar pressure) and the dependent variables extracted from the parent-reported questionnaires. They yield the same p-values as a corresponding linear regression and provide a convenient measure of effect size. Due to the exploratory nature of this research question, we identified a priori the following components of foot deformity which we hypothesised would be associated with the dependent variables: hindfoot equinus, hindfoot varus, forefoot supination, forefoot adduction and increased midfoot pressure. When interpreting the data we took

Table II. The mean and range of the average position of each segment in the gait cycle for all three groups. Welch ANOVA for all three groups and independent *t*-test (unequal variances assumed) between groups (*p < 0.05). Positive numbers = dorsiflexion, varus, supination, internal rotation, adduction. Negative numbers = plantarflexion, valgus, pronation, external rotation, abduction.

	Mean and range			Welch ANOVA (p-values)	Independent t-tests (p-values)		
	Control n = 30	Ponseti n = 31	Surgery n = 42	3 groups	Ponseti vs Control	Surgery vs Control	Ponseti vs Surgery
Hindfoot dorsiflexion (°)	2.1 (-4.5 to 8.1)	0.6 (-10.3 to 13.6)	1.4 (-19.9 to 12.4)	0.254			
Forefoot dorsiflexion (°)	-1.2 (-6.9 to 7.5)	-1.0 (-13.1 to 5.9)	-2.8 (-11.9 to 14.1)	0.159			
Forefoot/ Tibia dorsiflexion (°)	1.0 (-5.7 to 10.7)	1.4 (-15.3 to 8.2)	0.0 (-31.0 to 7.6)	0.540			
Hindfoot varus (°)	-3.3 (-10.6 to 5.4)	0.7 (-18.0 to 17.0)	-1.6 (-16.1 to 15.8)	0.055			
Forefoot supination (°)	6.6 (-2.4 to 14.7)	4.5 (-12.4 to 25.0)	8.6 (-5.4 to 36.4)	0.142			
Forefoot/ tibia supination (°)	3.3 (-1.8 to 9.8)	5.5 (-10.4 to 14.9)	6.8 (-7.0 to 32.5)	0.012*	0.071	0.008*	0.427
Hindfoot internal rotation (°)	2.4 (-6.6 to 15.8)	9.0 (-3.9 to 24.0)	8.6 (-6.0 to 26.9)	< 0.001*	< 0.001*	< 0.001*	0.799
Forefoot adduction (°)	1.3 (-7.7 to 13.5)	4.7 (-18.1 to 35.5)	-1.6 (-26.5 to 28.2)	0.095			
Forefoot/ Tibia adduction (°)	3.7 (-5.1 to 13.1)	13.5 (-17.8 to 45.1)	6.7 (-29.3 to 34.4)	0.002*	0.001*	0.206	0.040*

into account any outliers that affected the associations and checked scatter diagrams for non-linearity.

All analyses were completed using SPSS version 25, (IBM, Chicago, Illinois, USA). Significance levels were set at $p < 0.05$.

Results

Foot function during gait. ANOVA results revealed a significant difference between the FPS and all six FVS (Table I). Post hoc *t*-tests showed a significant difference for all variables between the surgical and control groups, as well as between the Ponseti and control groups, with the only exception being the forefoot in the coronal plane. When comparing the Ponseti and surgical groups, there were no statistically significant differences.

The comparison of the average position of each segment throughout the gait cycle between the club foot groups and control group (Supplementary Material Figure 1 (online supplementary figure 1; Table II) showed the surgery group had significantly increased forefoot supination relative to the tibia compared to the control group ($p = 0.008$). Both the Ponseti and the surgery groups had increased hindfoot internal rotation compared to the control group ($p < 0.001$). The Ponseti group had significantly increased forefoot adduction relative to the tibia compared to the control group ($p = 0.001$) and compared to the surgery group ($p = 0.04$).

There were no significant differences in range of forefoot motion between the groups in all three planes (Table III). The hindfoot in the surgery group had significantly reduced RoM compared to the control group in the sagittal and coronal planes ($p = 0.004$ and $p = 0.012$ respectively). Interestingly, the hindfoot in the transverse plane showed increased range of movement in both the Ponseti and surgery groups compared to controls ($p = 0.003$ and $p < 0.001$ respectively). In no instance was there a statistically significant difference between the Ponseti and surgery groups.

Significant differences were found across the three groups for all pressure measures except lateral forefoot

Table III. The mean and range of the flexibility (range of movement) of each inter-segment angle during the gait cycle for all three groups (prior to log transformation). Welch ANOVA for all three groups and independent *t*-test (unequal variances assumed) between groups following log transformation (*p < 0.05).

	Mean and range			Welch ANOVA (p-values)	Independent t-tests (p-values)		
	Control n = 30	**Ponseti n = 31**	**Surgery n = 42**	**3 groups**	**Ponseti vs Control**	**Surgery vs Control**	**Ponseti vs Surgery**
Hindfoot sagittal (°)	22.7 (14.8 to 34.4)	21.0 (13.3 to 30.8)	19.7 (13.7 to 33.1)	0.014*	0.135	0.004*	0.170
Forefoot sagittal (°)	16.1 (10.9 to 23.0)	15.7 (6.9 to 26.7)	15.1 (7.6 to 26.3)	0.299			
Hindfoot coronal (°)	10.5 (7.2 to 17.3)	10.8 (4.3 to 24.2)	9.1 (3.8 to 16.8)	0.036*	0.864	0.012*	0.069
Forefoot coronal (°)	8.1 (4.2 to 13.2)	8.6 (3.7 to 15.3)	9.9 (3.8 to 21.9)	0.218			
Hindfoot transverse (°)	16.0 (6.6 to 25.8)	20.4 (10.3 to 34.7)	23.3 (11.5 to 60.9)	< 0.001*	0.003*	< 0.001*	0.084
Forefoot transverse (°)	9.1 (4.5 to 16.6)	8.6 (4.2 to 25.6)	8.7 (3.3 to 24.7)	0.329			

Table IV. The mean and range of the plantar pressure measurements of all three groups (prior to log transformation). Welch ANOVA for all three groups and independent *t*-test (unequal variances assumed) between groups following log transformation (*p < 0.05).

	Mean and range			Welch ANOVA (p-values)	Independent t-tests (p-values)		
	Control n = 30	**Ponseti n = 28**	**Surgery n = 31**	**3 groups**	**Ponseti vs Control**	**Surgery vs Control**	**Ponseti vs Surgery**
Medial Hindfoot (kPa)	394.5 (175 to 605)	231.0 (88 to 402)	336.4 (53 to 998)	< 0.001*	< 0.001*	0.017*	0.053
Lateral Hindfoot (kPa)	348.7 (200 to 585)	198.9 (88 to 333)	231.1 (111 to 471)	< 0.001*	< 0.001*	< 0.001*	0.109
Midfoot (kPa)	38.7 (0 to 130)	118.7 (10 to 398)	132.0 (67 to 313)	< 0.001*	< 0.001*	< 0.001*	0.348
Medial Forefoot (kPa)	387.7 (155 to 940)	290.0 (115 to 555)	428.6 (100 to 1151)	0.010*	0.008*	0.761	0.008*
Lateral Forefoot (kPa)	260.0 (140 to 760)	246.5 (143 to 527)	319.7 (133 to 980)	0.136			
Total Peak Pressure (kPa)	481.7 (290 to 940)	357.4 (195 to 1067)	493.3 (230 to 1151)	0.001*	< 0.001*	0.637	0.005*
Force time integral (kPa.s)	184.0 (73 to 405)	195.6 (103 to 408)	231.7 (66 to 433)	0.004*	0.244	0.002*	0.013*

Table V. The frequency of reported pain in each subject taken from Question 4 of the OxAFQ: 'Has your child you had pain in their foot or ankle?

	always	very often	sometimes	rarely	never
Ponseti, n = 31	0	6	8	10	7
Surgery, n = 42	3	8	14	7	10

OxAFQ, Oxford Ankle Foot Questionnaire

pressure (Table IV). Both the medial and lateral hindfoot pressures were reduced for the Ponseti compared to the control group (p < 0.001 for both) and the surgery compared to the control group (p = 0.017 and p < 0.001 respectively). Midfoot pressures were significantly increased in both Ponseti and surgery groups compared to the control group (p < 0.001). Medial forefoot pressure was reduced in the Ponseti group compared to the control group (p = 0.008) and compared to the surgery group (p = 0.008). Total peak pressure was reduced in the Ponseti group compared to the control group (p < 0.001) and compared to the surgery group (p = 0.005).

Table VI. The mean and range of the Paediatric Quality of Life Questionnaire (PedsQL), Disease Specific Index (DSI) and Oxford Ankle Foot Questionnaire (OxAFQ) for the Ponseti and surgical groups. Independent *t*-test (unequal variances assumed) between groups (*p < 0.05).

		Mean (range)		
		Ponseti	**Surgery**	**p-value**
PedsQL	**PhysHealth**	77.0 (47 to 100)	75.7 (31 to 100)	0.852
Ponseti, n = 22	**PsychSoc**	75.1 (16 to 100)	82.9 (61 to 100)	0.228
Surgery, n = 13	**Total Score**	75.5 (31 to 97)	80.4 (54 to 100)	0.418
DSI	**Satisfaction**	65.6 (40 to 100)	54.4 (26 to 80)	0.031*
Ponseti, n = 25	**Function**	62.1 (20 to 100)	56.9 (6 to 100)	0.394
Surgery, n = 13	**Total Score**	65.1 (37 to 90)	55.6 (33 to 90)	0.107
OxAFQ	**Physical**	64.1 (12.5 to 100)	58.2 (12.5 to 100)	0.323
Ponseti, n = 31	**School & Play**	80.0 (19 to 100)	78.4 (25 to 100)	0.771
Surgery, n = 42	**Emotional**	83.1 (19 to 100)	69.7 (12.5 to 100)	0.016*

Force time integral was increased in the surgery group compared to control group (p = 0.002) and compared to the Ponseti group (p = 0.013).

Perceived disability. The frequency of pain reported in the Ponseti and surgery groups was similar (Table V). Overall, the surgery group scored lower than the Ponseti group in the DSI and the OxAFQ, but the only statistically significant differences between the groups were in the Satisfaction subscale of the DSI (p = 0.031) and the Emotional domain of the OxAFQ (p = 0.016) (Table VI).

Association of foot function and perceived disability. The correlations of the gait data with subjective outcome measures are presented in Tables VI-VIII in the Supplementary Material (online supplementary figure 1). We were particularly interested in the associations with foot function variables that we identified a priori in our hypotheses. The variables representing hindfoot equinus (RoM in the sagittal plane, hindfoot sagittal FVS, and reduced pressure in the heel regions) all demonstrated significant associations with each of the subjective questionnaire scores, although these differed according to club foot group and gait variable being considered. This was similarly the case for variables representing hindfoot varus (coronal hindfoot RoM and peak pressure under the medial aspect of the foot compared to the lateral), forefoot supination (coronal forefoot FVS and RoM), forefoot adduction (transverse forefoot FVS and RoM), and midfoot pressure. Results overall indicated that the foot function variables we identified were associated with poorer subjective outcomes.

Discussion

Our findings suggest that children with symptomatic club foot deformity, whether treated by Ponseti or surgery, present with similar degree of deficits in foot function during gait as well as a similar level of perceived disability. Therefore we accept the hypothesis that both club foot treatment groups are different to controls. However, we cannot conclude that the two club foot groups are different to each other with respect to foot function or subjective outcomes.

This is the first study to investigate children who are symptomatic following their initial club foot correction, regardless of whether they were treated with the Ponseti method or surgery. The uniqueness of our cohort is confirmed by our lower DSI scores compared to the literature.[16,25]

Both club foot groups had increased FPS and FVS compared to normal, which indicates impaired foot function during walking. However, they were not statistically significantly different to each other. The position of the forefoot and hindfoot showed that under-correction or over-correction occurred in both club foot groups. The only statistically significant difference between the groups was increased forefoot adduction relative to the tibia in the Ponseti group compared to both the surgical and the control groups. Both club foot groups showed significantly reduced peak hindfoot pressure and increased midfoot pressure compared to controls. The Ponseti group had reduced medial forefoot pressure compared to both surgery and controls groups.

Other club foot studies have reported stiffness in the sagittal hindfoot using the OFM in a surgical population compared to a Ponseti population, Svehlik et al[17] and Mindler et al[16] found this in a Ponseti population compared to controls. Jeans et al[9] investigated a Ponseti population and found compared to controls, similar to our results, they had reduced plantar pressure in the hindfoot and increased pressure in the midfoot. Converse to our results, Salazar et al[8] compared Ponseti and surgery groups using plantar pressure and found the Ponseti group had reduced peak hindfoot pressure and increased midfoot pressure compared to their surgical population. Differences are likely due to the populations studied.

This is the first study to correlate gait data with perceived disability in children treated for club foot. Multiple exploratory correlations were assessed to identify relationships between the gait data and subjective questionnaires. It is important to note that the OxAFQ had the most responses and therefore the most emphasis should be put on associations found using this outcome measure. Despite the similarities in gait and subjective outcomes between the club foot groups, the Ponseti and surgery groups behaved differently in how their gait deviations related to subjective outcomes.

In the Ponseti group, perceived disability was associated with hindfoot equinus, increased peak midfoot pressures, reduced peak medial forefoot pressures, and reduced RoM of the hindfoot in the coronal plane. This suggests that children who have these residual deformities are more likely to have poor subjective outcomes. Therefore good initial correction of hindfoot equinus with a tenotomy, as well as full subtalar correction in the casting phase may be important in this population.

In the surgical group, perceived disability was associated with coronal forefoot deformity, reduced RoM of the forefoot in the sagittal plane and of the hindfoot in the sagittal and coronal planes. This suggests that post-surgical correction, children who have residual forefoot supination or residual stiffness of the forefoot and hindfoot in the sagittal plane, or stiffness of the hindfoot in the coronal plane are likely to have poor subjective outcomes.

It is important to acknowledge the large inter-individual variation within the club foot subjects (Online supplementary figure 1). It is therefore difficult to make generalisations and recommendations based on a child's previous treatment (Ponseti or surgery) as both contain the entire spectrum of deformity with no specific pattern. This supports the view that each child should receive an individualized approach when seeking further management.

An interesting outcome of our study was that the three subjective outcome measures showed very little agreement in correlations with the gait data. This might be expected with a generic health measure like the PedsQL, but the DSI was designed for use in club foot,[23] and the OxAFQ was validated using club foot as one of its populations.[22] One possibility is that these measures are not sensitive enough to correlate with foot function defined by 3D gait analysis. The link between body function, participation and quality of life has not yet been well defined for this population, which justifies future research in this area.

Study limitations. Specific details of severity of the original deformity, such as the Pirani Score, and initial success of the Ponseti method or surgery were unknown due to the nature of tertiary referral. We recognize the many correlations examined may bring up false positive associations. Therefore we only put emphasis on those we had hypothesised a priori. A larger study would be needed to further explore our preliminary findings. Lastly, due to subdividing the club foot subjects into two groups and only having a subset of data for the PedsQL and DSI, some of the associations were more prone to outliers. We did our best to acknowledge when outliers were affecting statistically significant associations.

Conclusion

Our findings suggest that children with symptomatic club foot deformity present with a similar amount of gait deviations and perceived disability whether treated by the Ponseti method or surgery. Hindfoot deformity in the sagittal plane and forefoot and hindfoot deformity in the coronal plane were associated with perceived disability, regardless of whether they had received the Ponseti method or surgery.

Supplementary material

Comparison of the average position of each segment throughout the gait cycle between the club foot groups and control group.

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