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Original Article

Rate of return to the physiotherapy department of infants with brachial plexus birth injuries in three residential areas of Zanzibar, the United Republic of Tanzania

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Abstract. [Purpose]The purpose of this study was to clarify the rate of return to the physiotherapy department of infants with brachial plexus birth injuries in three residential areas of Zanzibar. [Participants and Methods]A total of 30 infants diagnosed with brachial plexus birth injuries who were brought to the physiotherapy department of Mnazi Mmoja Hospital were evaluated. Infants were divided into three groups based on the area of residence: urban, peri-urban, and rural. The rates of return for infants from these 3 areas at the ages of 1 month, 3 months, and 6 months were compared using a chi-square test. [Results]Significant differences in the rate of return were observed among infants from the 3 areas at 1 month and 3 months of age. No significant difference was observed at 6 months of age. [Conclusion]The rate of return of infants from rural areas was lower at 1 month of age and higher at 3 months of age than that of infants from other areas. At 6 months of age, the rate of return was not significantly different among residential areas.

Key words: Zanzibar, brachial plexus birth injury, rate of return

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1. INTRODUCTION

The author was dispatched to the United Republic of Tanzania (Fig. 1) as part of the Japan Overseas Cooperation Volunteers (JOCV) operated by the Japan International Cooperation Agency (JICA) and worked for technological transition project as a physiotherapist at Mnazi Mmoja Hospital on Unguja island, Zanzibar (Fig. 2). Tanzania has a population of 51.82 million and a total land area of 945,000 square kilometers. Tanzania has a gross national income per person of 920 USD and is thus classified as a least developed country[1]. With regard to health and medical care in Tanzania, the average lifespans of males and females are 59.9 and 63.8 years, respectively, with an overall mean lifespan of 61.8 years[2]. The state of maternal and child health is especially poor. The maternal mortality rate is 398 per 100,000 live births, and the neonatal and under-5 mortality rates are 18.8 and 48.7 per 1,000 live births, respectively[2]. Because the total fertility rate is 4.77[3], physiotherapy for pediatric patients is urgently needed. Mnazi Mmoja Hospital is the only national hospital and houses the only rehabilitation department in Unguja island, which

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has a population of 896,721 and a total land area of 1,666 square kilometers[4]. The physiotherapist treats patients throughout the entire region. The frequency of doctor visits may be influenced by the residential area of the patient. Medical differences between urban and rural areas in mainland Tanzania have been described. Singh examined factors influencing the higher prevalence of HIV infection among urban women than among rural women[5], and Ohnishi observed that almost all school-age children in each region and location had eaten at least one carbohydrate-rich food per day[6]. In Zanzibar, Knopp described patterns and risk factors of helminthiasis and anemia in a rural and peri-urban community[7], and Schaetti described social and cultural features of cholera and shigellosis in peri-urban and rural communities[8]. These studies report investigations of diseases, nutrition, and awareness. However, there is no report comparing the frequency of hospital visits between urban areas and rural areas. The authors have reported the validity of the simple brachial plexus birth injury (BPBI) assessment scale in Zanzibar[9]. The purpose of this study was to compare the rate of return of infants with BPBIs to the physiotherapy department in Zanzibar from different residential areas.

Fig 1. United Republic of Tanzania

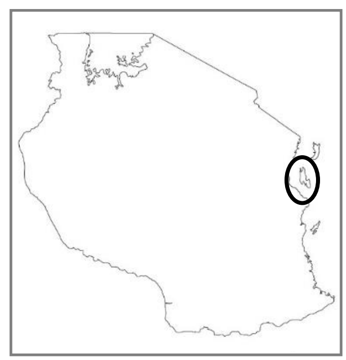

Fig 2. Unguja island, Zanzibar

2. SUBJECTS AND METHODS

The participants were 30 infants (20 males and 10 females) born between April 2014 and June 2015 with a diagnosis of BPBI who visited the Mnazi Mmoja Hospital physiotherapy department. Their rate of return to the physiotherapy department was recorded for 6 months. Local doctors initially diagnosed the BPBI but patients could directly visit the physiotherapy department without a referral from a doctor in Tanzania. For patients who visited the physiotherapy department directly without a referral, multiple physiotherapists comprehensively diagnosed BPBI on the basis of negative Moro reflex, negative grasp reflex, and the lack of lower limb symptoms. Cerebral palsy was excluded. Utilizing Tanzanian census data4), the residential areas of the infants were classified as follows: urban [Mjini (city)], peri-urban [Magharibi (west)], and rural [Kaskazini (north) A, Kaskazini B, Kati (central), and Kusini (south)]. In this study, the urban, peri-urban, and rural groups comprised 5, 19, and 6 infants, respectively. Mnazi Mmoja Hospital was located in the urban region. The distance from the hospital to major cities in each area was as follows: approximately 7 km to Tomondo in the west, approximately 59 km to Nungwi in the north A, approximately 22 km to Kitope in the north B, approximately 15 km to Kidimni in the central region, and approximately 55 km to Jambiani in the south. The infants were referred to the physiotherapy department within the first month after birth, and their mothers were advised to visit physiotherapy department approximately every 3 to 4 weeks. As a statistical comparison, the rates of return among the 3 residential areas at the ages of 1 month, 3 months, and 6 months were compared by chi-square test. P-value <0.05 was considered statistically significant. The residential area of each infant was recorded in their medical record. This study is a retrospective study of data obtained during the period of activities conducted by the JOCV. The study was approved by the Ethics Review Committee of the International University Health and Welfare, Japan (approval number: 16-Io-141). We also obtained a letter of consent from Mnazi Mmoja Hospital.

3. RESULTS

Table 1 shows the rate of return to the physiotherapy department of infants with BPBIs from urban, peri-urban, and rural areas for each age group. In the statistical analysis, significant differences were found among infants from the 3 areas at both 1 month and 3 months of age ($p < 0.05$). No significant difference among infants from the different residential areas was seen at 6 months of age.

Table 1. Rate of return to the physiotherapy department at each age

Age	Urban (%)	Peri-urban (%)	Rural (%)	P-value
1 month*	20.0	31.6	16.7	0.03
3 months *	40.0	26.3	50.0	< 0.01
6 months	40.0	47.4	50.0	0.34

Chi-square test *p<0.05

4. DISCUSSION

The Republic of Zanzibar merged with mainland Tanganyika in 1964[10]. Combining the two names, this United Republic of Tanganyika and Zanzibar was soon renamed as the United Republic of Tanzania, within which Zanzibar remains a semi-autonomous region[10]. Because of this history, medical care and life are often completed within Zanzibar, and Mnazi Mmoja Hospital plays an important role. According to this study, at 1 month of age, the rate of return of BPBI patients from rural areas was lower, while the rates of return of patients from urban and peri-urban areas were higher. This result appears to be associated with the time required to travel from the patient’s home to the hospital. As it takes approximately two hours by bus to travel from Mnazi Mmoja Hospital to the northern and southern ends of the country, mothers experience difficulty when traveling to the hospital with their neonate. The rates of return for rural patients were significantly higher at 3 months of age, as an infant is often able to hold his or her head up around that time, and mothers were more likely to travel to the hospital with their baby. As there are no differences observed at 6 months of age, we presume that BPBI infants requiring physiotherapy are taken to the hospital by their families at the same rate, regardless of their residential areas. The 30 infants in this study represented all of the new BPBI patients for 15 months from April 2014 to June 2015. The census reported 22,645 births on Unguja island in 2014[4]. If we divide the 15-month incidence by the projected 15-month birth number (annual birth number multiplied by 1.25), the approximate incidence of BPBI is found to be 1.1 per 1,000 live births. Referring to earlier reports, the incidence of BPBI was about 0.9 to 5.1 per 1,000 live births[11]. Given this calculation, it is expected that Mnazi Mmoja Hospital will be able to manage most BPBI patients on the island and fulfill its role as the island’s core hospital. Physiotherapists or occupational therapists from the Mnazi Mmoja Hospital rehabilitation department infrequently visited the rural areas in northern and southern regions to administer medical treatment. The results of this study suggest that physiotherapy is necessary for rural neonates who experience difficulty traveling to the hospital. In September 2014, a second physiotherapy training school opened in Zanzibar, Tanzania[12]. In the future, the results from our study may help in the development of a new training school, taking regional characteristics into account. In this study, we studied only BPBI patients. However, it is also important to consider other pediatric patients of various ages in the future. A limitation of this study is that BPBI patients are also affected by their families' circumstances and thus may encounter financial obstacles such as bus fees.

Funding and Conflict of interest

No funding was provided for this study. The author declares no conflict of interest.

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Original Article

Influence of different foot positions on pelvis and trunk motions

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Abstract. [Purpose] This study was conducted with the objective of clarifying the kinetic chain caused by the differences in the right and left foot positions on the pelvis, thorax, and spinal column.[Subjects and Methods] The dynamics of the body segments during standing rotation and side-bending motion were analyzed in 12 healthy subjects using a three-dimensional motion analysis system. In the experiments, the right foot was in pronation and the left in supination. A ramp with tilt angles of 0°, 10°, and 20° was placed under the sole of the foot. [Results] The analysis results showed that during rotation, the amount of pelvic rotation was larger in supination than in pronation. Furthermore, the range of motion of the internal rotation of the hip joint on the rotation side was large for the left and right sides. During side-bending motion, the foot position had less effect on each segment. However, even for the same motion task, the change in the angles of the right and left sides of each body segment was reversed depending on the tilt angle of the sole part. [Conclusion] These results suggests that attitude control may be prioritized over the kinetic chain as the tilt angle increases.

Key words: Foot position, Trunk motion, Kinetic chain

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1. INTRODUCTION

Conventionally, physical therapy for musculoskeletal disorders have focused on range of motion and muscle strengthening exercises for the diseased parts. However, it has been suggested in recent years that the functional impairment of diseased sites affects adjacent joints and that inefficient movement patterns may be involved in the development of musculoskeletal disorders. Therefore, physical therapy has shifted from considering only the affected part to considering the multijoint kinetic chain.

Steindler defined the “kinetic chain” as “the motion spreading to the adjacent joint when joint motion occurred”[1]. The kinetic chain is an important concept in the fields of rehabilitation and sports medicine. In this regard, the kinetic chain of the foot and lower leg is extremely important. The tibia rotates internally when the calcaneus is everted, and externally under calcaneal inversion. The change in the angle of the tibia with respect to that of the calcaneus was reported to be 1/2 (Hintermann, 1994)[2]. The tibia and hip joint rotate internally when both feet are pronated in the standing position[3]. Specifically, when turning was performed with a plate inclined at 20° inserted in the sole of the foot, the tibia and hip joint were reported to rotate by 5° and 3°, respectively (Khamis, 2007)[4]. As pronation of the foot position increases, the hip joint rotates inward and the pelvis bends forward (Pinto, 2007)[5].

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Previous studies provide findings that are considerably important for joint diseases of the lower limbs[6)7)]. However, they all have certain shortcomings. First, they measured the foot position under the left and right leg conditions. However, patients with joint dis-eases cannot easily reproduce the conditions of these previous studies because their left and right leg positions differ. Second, they only analyzed the kinetic chain of adjacent joints. It is well-known that the spreading effect decreases as the kinetic chain becomes more distal from the starting point. However, the extent to which the body spreads remains unclear. Third, they all measured a single exercise task, whereas new and additional information could be obtained by analyzing a kinetic chain with multiple kinematics tasks. Therefore, in this study, we analyzed the rotation and side-bending motion of the body under different left and right foot conditions and clarified the influence of the foot position on other joints.

2. SUBJECTS AND METHODS

For this study, 12 healthy subjects (average age: 20.5 ± 0.5 years, height: 169.4 ± 6.9 cm, body weight: 60.2 ± 9.8 kg) were recruited. Subjects who had joint disorders, surgical history of the lower extremities, diseases and deformities of the spinal column, or neurological disorders were excluded. The study purpose was clearly explained to all subjects in advance, and the study was conducted by considering the subjects' physical and mental burden. The study protocol was approved by the International University of Health and Welfare Ethics Review Committee (Approval number 15-Ifh-76).

The subjects' body kinematics were measured using a three-dimensional motion analyzer (VICON NEXUS:VICON Co. Ltd. UK) with eight infrared cameras at a sampling frequency of 100 Hz. Infrared reflective markers with a diameter of 14 mm were affixed to 35 locations on each subject's body and a plug-in-gait full body model adopted.

Measurement was conducted for rotation of the body and side-bending motion in the natural standing position. In the rotation motion, the body was rotated backward as much as possible in 3 sec. after standing at rest for 3 sec., and the action of returning to the front in 3 sec. was performed three times for the left and right sides. The side-bending motion involved bending laterally as much as possible in 3 sec. after standing at rest for 3 sec., and the action of returning to the front in 3 sec. was performed three times for the left and right sides. The subjects were barefoot in these experiments. The distance between the feet was considered as the subject's foot length, and the foot angle was set to 10°. A ramp with tilt angles of 10° and 20° was inserted under the sole of the foot such that the right foot was in pronation and the left foot was in supination (Fig. 1). A metronome was used to adjust the motion speed, and spats were worn to minimize measurement error due to garment displacement. The upper limbs were held in front of the abdomen, and the positions of the head and shoulders were not prescribed.

Thigh, pelvis, thorax, and spinal column segments were created using 3D motion analysis calculation software (VICON WORK STATION: VICON Co. Ltd. UK). The femoral segment includes both thighs and both femoral lateral epicondyles; pelvic segment, both anterior superior iliac spines and both superior posterior iliac spines; thorax segment, the seventh cervical spinous process, tenth thoracic spine process, right scapula, jugular notch, and xiphoid process prepared using coordinate data. For the reference coordinates of the laboratory, the X axis was defined as the anterior–posterior axis, the Y axis as the mediolateral axis, and the Z axis as the proximal–distal axis. The basic axis and the motion axis for each body segment were set, and the angle change amount was measured.

The change in the angle of each body segment was calculated as the average of three values by calculating the difference between the angles before and after the motion task. The normality of data was confirmed using the Shapiro–Wilk test. The change in angle of each body segment due to the difference in the direction of motion of the body was compared using the Mann-Whitney U test. The amount of change in the angle of the hip joint during motion of the body was compared using the Mann-Whitney U test. The amount of change in angle between each body segment during motion of the body by angle of inclination was compared using the Kruskal-Wallis (post hoc; Steel-Dwass) test. EZR on R commander (1.6-3) was used for statistical processing, and the significance level was set to 5%.

Fig.1. Ramp with tilt angles of 10° and 20° was inserted under the sole of the foot so that the right foot was in pronation and the left foot was in supination.

3. RESULTS

A comparison of the change in the angles of the pelvis, thorax, and spinal column during body rotation to the left and right showed that the change in the angle of the pelvis was significant at left rotation for inclination angles of 10° and 20° ($p < 0.05$) (Table 1). The same comparison during side-bending motion to the left and right showed no significant difference for all body segments ($p < 0.05$) (Table 2). A comparison of the change in the angle of the hip joint during body rotation to the left and right showed that the internal rotation of the right hip joint was significant ($p < 0.05$) for body rotation to the right at an inclination angle of 0°; in addition, the internal rotation of the left hip joint was significant ($p < 0.05$) for body rotation to the left. At a tilt angle of 10°, left hip joint rotation was significant ($p < 0.05$) for body rotation to the left. At a tilt angle of 20°, right hip joint rotation was significant ($p < 0.05$) for body rotation to the right (Table 3). For side-bending motion to the left and right there was no significant difference in the change in the angle of the hip joint for inward and outward rotation at all inclination angles (Table 4). For the angles of the pelvis, thorax, and spinal column during body rotation, there was no significant difference in the change under all inclination angles (Table 5). Further, for side-bending motion of the body there was also no significant difference in the angle changes for all body segments (Table 6).

Table 1 Comparison of angular variation of each body segment during body rotation

Tilt angles	Segment	Body rotation	
		Right	Left
0°	Pelvis(°)	48.9 ± 8.8	54.4 ± 14.4
	Thorax(°)	74.5 ± 10.1	80.5 ± 20.7
	Spinal column(°)	24.0 ± 9.3	24.3 ± 10.7
10°	Pelvis(°)	42.1 ± 9.0	52.3 ± 11.8*
	Thorax (°)	69.5 ± 11.8	76.8 ± 15.9
	Spinal column(°)	25.1 ± 8.8	22.9 ± 7.0
20°	Pelvis(°)	41.8 ± 13.8	48.4 ± 8.3*
	Thorax(°)	68.8 ± 10.4	71.5 ± 16.9
	Spinal column(°)	25.8 ± 10.4	23.8 ± 11.9

*p<0.05

Table 2 Comparison of angular variation of each body segment during body side-bending

Tilt angles	Segment	Body side-bending Right	Left
0°	Pelvis(°)	8.1 ± 4.3	8.7 ± 4.9
	Thorax(°)	38.4 ± 5.1	43.1 ± 5.8
	Spinal column(°)	29.5 ± 6.5	34.2 ± 5.8
10°	Pelvis(°)	8.3 ± 4.1	7.7 ± 4.1
	Thorax(°)	38.2 ± 4.8	38.4 ± 6.5
	Spinal column(°)	29.3 ± 6.4	30.6 ± 6.3
20°	Pelvis(°)	9.0 ± 5.3	8.4 ± 3.7
	Thorax(°)	40.2 ± 8.5	31.5 ± 6.8
	Spinal column(°)	31.4 ± 6.1	31.5 ± 6.9

＊$p<0.05$

Table 3 Comparison of angular change of both hip joints during body rotation

Body rotation	Tilt angles	Right hip joint Internal rotation(°)	Left hip joint External rotation(°)
Right	0°	12.5 ± 3.4	8.2 ± 3.6*
	10°	10.7 ± 4.5	8.1 ± 3.4
	20°	10.1 ± 3.2	7.0 ± 3.5*

Body rotation	Tilt angles	Right hip joint External rotation(°)	Left hip joint Internal rotation(°)
Left	0°	9.8 ± 4.3	14.1 ± 4.2*
	10°	9.7 ± 4.5	13.7 ± 3.6*
	20°	9.3 ± 3.4	11.2 ± 6.0

＊$p<0.05$

Table 4 Comparison of angular change of both hip joints during body side-bending

Body side-bending	Tilt angles	Right hip joint Adduction(°)	Left hip joint Abduction(°)
Right	0°	10.4 ± 5.1	10.0 ± 4.8
	10°	10.2 ± 5.1	9.9 ± 4.9
	20°	11.4 ± 6.0	11.2 ± 6.0

Body side-bending	Tilt angles	Right hip joint Abduction(°)	Left hip joint Adduction(°)
Left	0°	9.9 ± 4.7	10.2 ± 4.9
	10°	8.6 ± 4.2	9.2 ± 4.6
	20°	9.5 ± 4.3	10.2 ± 4.8

＊$p<0.05$

Table 5 Comparison of angular variation of each body segment during body rotation by angle of inclination

Body rotation	Segment	Tilt angles		
		0°	10°	20°
Right	Pelvis(°)	48.9 ± 8.8	42.1 ± 9.0	41.8 ± 13.8
	Thorax(°)	74.5 ± 10.1	69.5 ± 11.8	68.8 ± 10.4
	Spinal column(°)	24.0 ± 9.3	25.1 ± 8.8	25.8 ± 10.4
Left	Pelvis(°)	54.4 ± 14.4	52.3 ± 11.8	48.4 ± 8.3
	Thorax(°)	80.5 ± 20.7	76.8 ± 15.9	71.5 ± 16.9
	Spinal column(°)	24.3 ± 10.7	22.9 ± 7.0	23.8 ± 11.9

＊ $p<0.05$

Table 6 Comparison of angular variation of each body segment during body side-bending by angle of inclination

Body side-bending	Segment	Tilt angles		
		0°	10°	20°
Right	Pelvis(°)	8.1 ± 4.3	8.3 ± 4.1	9.0 ± 5.3
	Thorax(°)	38.4 ± 5.1	38.2 ± 4.8	40.2 ± 8.5
	Spinal column(°)	29.5 ± 6.5	29.3 ± 6.4	31.4 ± 6.1
Left	Pelvis(°)	8.7 ± 4.9	7.7 ± 4.1	8.4 ± 3.7
	Thorax(°)	43.1 ± 5.8	38.4 ± 6.5	31.5 ± 6.8
	Spinal column(°)	34.2 ± 5.8	30.6 ± 6.3	31.5 ± 6.9

＊ $p<0.05$

4. DISCUSSION

The change in the angle of each body segment during rotation showed no difference at an inclination angle of 0°. However, at tilt angles of 10° and 20°, the change in the angle of pelvis rotation was significant on the supination side of the foot. During rotation of the body, the pelvis is known to rotate in the forward direction at the pronation side and the backward direction at the supination side. In addition, it is a favorable condition for posterior rotation of the pelvis because the stiffness of the feet becomes high at the supination of the foot and lateral movement of the foot pressure center becomes possible. Therefore, it is considered that the change in the angle of pelvic rotation increases on the supination side of the foot.

There was no lateral difference in the change in the angle of each body segment during side-bending motion at all inclination angles. Therefore, it is considered that the foot position and tilt angle may have less influence on the motion of the frontal plane of each body segment. The change in the internal rotation angle on the rotation side was significantly higher than that in the external rotation angle on the non-rotation side in four out of six conditions of body rotation. This indicates that during body rotation in healthy subjects, the internal rotation range of the hip joint on the rotation side is important. However, there was no significant difference between body rotation to the right with a tilt angle of 10° and body rotation to the left with a tilt angle of 20°.

Originally, the kinetic chain spreads with a change in the alignment of a few body segments as a starting point. The larger the change in the starting point of motion, the larger the ripple effect should be in the same direction. However, the results of this study do not necessarily agree with these hypotheses. It has been reported that attitude control takes precedence over the kinetic chain when the tilt angle is excessively increased with one leg standing using a ramp (Tateuchi, 2011)[8]. The same phenomenon may have occurred in this study. In other words, if the foot is supinated excessively, the amount of displacement of the lower limb loading axis to the outside increases and it becomes difficult to maintain posture. Therefore, it may be necessary to prioritize posture control over the kinetic chain.

Next, a comparison of the change in the angle of the hip joint during side-bending motion showed no differences for the left and right sides at all inclination angles. Therefore, it is considered that the foot position and inclination angle may have less influence on hip joint motion. The change in the angles of the pelvis, thorax, and spinal column according to inclination angle showed no significant difference for rotation and side-bending motion. Because body rotation is mainly performed by the hip joint, it is considered that there was no difference in the change in the angles of the proximal body segments, namely, the pelvis, thorax, and spinal column. For this reason, it is considered that the foot position and tilt angle have only a slight influence on the motion of each body segment.

The clinical relevance of this study is that it shows that it may be possible to alleviate back pain in general by adjusting the amount of pelvic rotation using the sole plate and to alleviate lower back pain by expanding the range of motion of the hip joint. A limitation of this study is that it is unclear whether the inclination angle of the set foot is unrealistic in clinical application and whether the same kinetic chain occurs in musculoskeletal disorder patients because the subjects were healthy. We consider that it is necessary to subdivide the inclination angle and recruit subjects with musculoskeletal disorder to verify it in more detail in future work.

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