Evaluation of Gait in Albanian β-thalassemia Patients

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Abstract

One of the most prevalent genetic diseases in the world is beta thalassemia. Hemoglobin synthesis is decreased by the blood condition beta thalassemia. Patients with thalassemia exhibit a range of bone problems, including as spinal deformities, osteopenia and osteoporosis, as well as growth failure. This study's main goal was to evaluate gait and balance in Albanian β-thalassemia patients. In this study, 18 participants aged 17 to 29 years old *(5 males and 13 females)* from three distinct epidemiological cities in Albania took part. Gait analysis was performed using "*T&T medilogic medizintechnik gmbh*" wi-fi insoles. "General Gait Parameters", results of the "Effective Foot Length, left [%]" parameter mean results [67.59%], reveals approx a 2% difference compared with the relative normative mean [69.7%]. Also, "Effective Foot Length, left [%]" mean results [65.49%], reveals approximately a 3.5% difference compared with the relative normative mean [69.7%]. "General Gait Parameters", data comparisons revealed statistically significant differences between "is" and "nom." measurements for the following variables: "Rel Double Step Length", "Double Step Duration", "Effective Foot Length Right" and "Width Of Gait Right" ($p<0.005$). Results for the rest of the variables shwed a not statistically significant difference. The aim of the study was to assess the gait parameter in Albanian individuals with thalassemia. Based on the result of the "General Gait Parameters", data reveal a difference in the % of the average gait line which is related to effective distribution in the insole length showing a specific indication of insecure gait. According to the findings, gait issues are a significant health issue for beta thalassemia patients which are most likely caused by disease-related side-effects such high calcium levels after blood transfusions, inactivity caused by insufficient muscle mass, and all other health-related disease conditions. It is advised that the gait analysis exam to be included in their regular health check-ups. Future studies should be conducted involving larger ß-thalassemia patients take into account the unique state of this category to better evaluate the gait problems related with general static and dynamic posture problems. Clinicians' health specialists and rehabilitation experts when planning B-Thal rehabilitation programs sholud use gait analysis exam as a regular health check-up.

Keywords: Gait analysis, Evaluation, β-thalassemia patients

Introduction

A hereditary condition of hemoglobin synthesis known as beta-thalassemia causes a reduction in the production of the b-globin chain. Intramedullary hemolysis and inefficient erythropoiesis are caused by a relative imbalance of the alpha and beta globin genes. Lifelong transfusion treatment is used to treat this disease, which can cause iron excess and toxicity. It has been demonstrated that multiorgan illness is brought on by iron accumulation in the heart, liver, and endocrine glands. The most severe iron-mediated consequence and the main reason for mortality in those with thalassemia major is cardiomyopathy (Borgna-Pignatti C et al., 2004; Modell B et al., 2000; Zurlo MG et al., 1989). The quality of life (QoL) of thalassemia patients is anticipated to be impacted by some of the major clinical and psychological aspects of the condition, such as: (1) having a chronic condition and the subjective feeling of being different; (2) physical changes, such as bone deformities and short stature, which affect one's self-image; (3) treatment (transfusions and iron chelation therapy); (4) delayed or absent sexual development and issues with fertility; (5) heaving; and (5) he (Telfer P et al., 2005; Mikelli A et al., 2004). Changes in bone architecture, bone quality, and mineral density are among the main impacts of thalassemia on the bones. Other serious morbidities include osteoporosis, fractures, spinal abnormalities, nerve compression, and discomfort. Baldini M. et al., 2017; Steer K. et al., 2017; Baldini M. et al., 2014).

Gait Analysis

The coordination, balance, and synchronization needed for gait are activated by the appropriate operation of the central and peripheral (musculoskeletal) neural systems. Each person's gait characteristics are drastically variable depending on their physical and mental health, resulting in a distinctive pattern (Horst, F et al., 2017). The gait cycle, which is similar to a stride and consists of two subsequent steps, is used to assess gait. A gait cycle has the following phases: (a) the stance phase, which lasts until the same foot leaves the ground, and (b) the swing phase, which starts when the foot leaves the ground. Speed affects a number of gait factors, and speed also depends on body height. On the other hand, when it comes to techniques and modern tools for evaluating gait analysis, sensor insoles are one of the most cutting-edge options available today since each gait event can be defined by a pressure pattern (Daz, S. et al., 2020). Unstable gait is frequently seen in people with neurological and musculoskeletal diseases because it compromises the capacity to control where the body's center of mass (COM) is in relation to the base of support (BOS) (Albertsen, I. M et al., 2017; Kristiansen, M et al., 2019).

Objectives

Main objective of this study was to evaluate gait and balance in Albanian β-thalassemia patients.

Methodology

In this study, 18 participants aged 17 to 29 years old *(5 males and 13 females)* from three distinct epidemiological cities of Albania. Gait analysis was performed using "*T&T medilogic medizin technik gmbh*" wi-fi insoles (Figure 1, 2, 3). For the measuring setup, a 10-m flat indoor walking area was utilized.

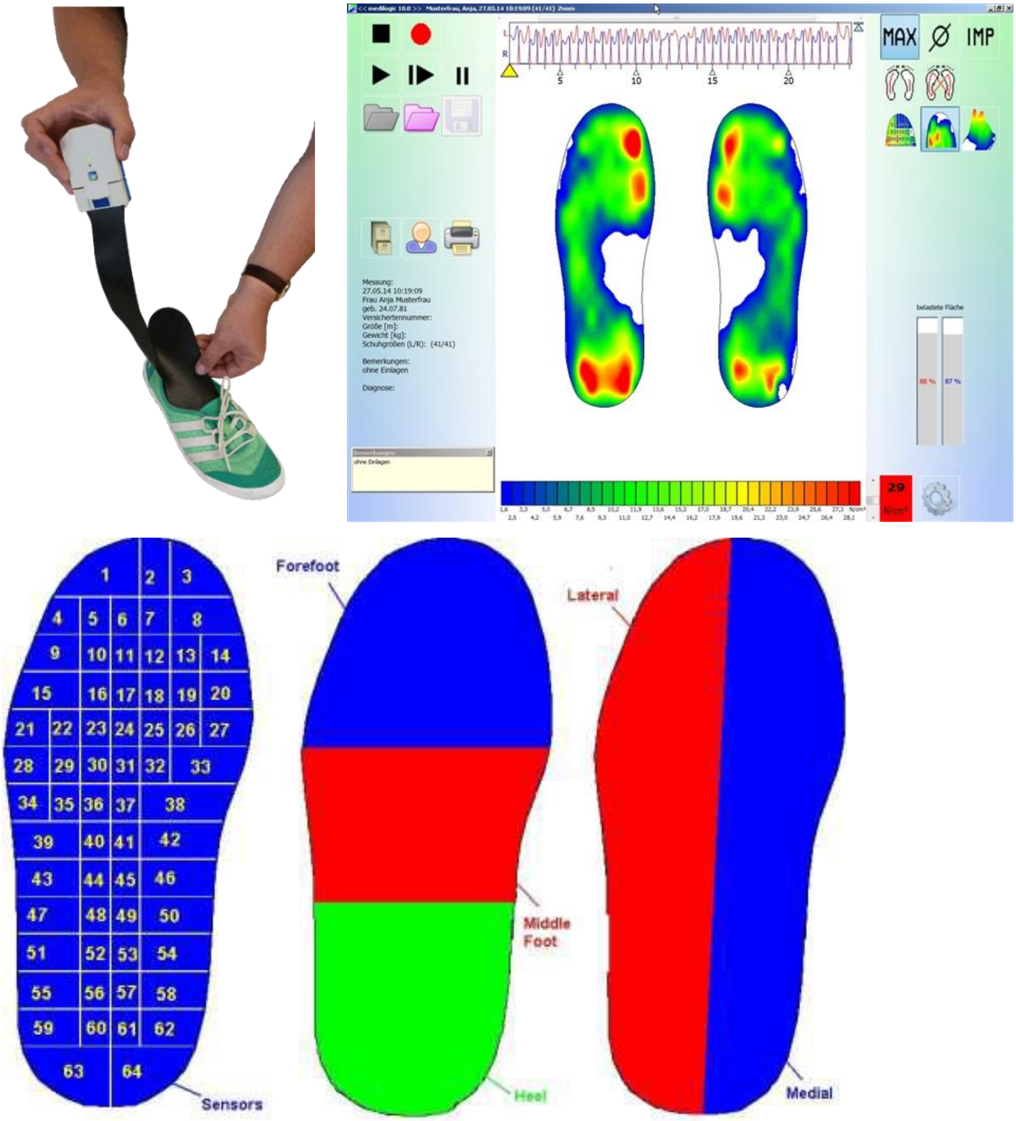

Figure: 1, 2, 3. *T&T medilogic medizin technik gmbh*" wi-fi insoles

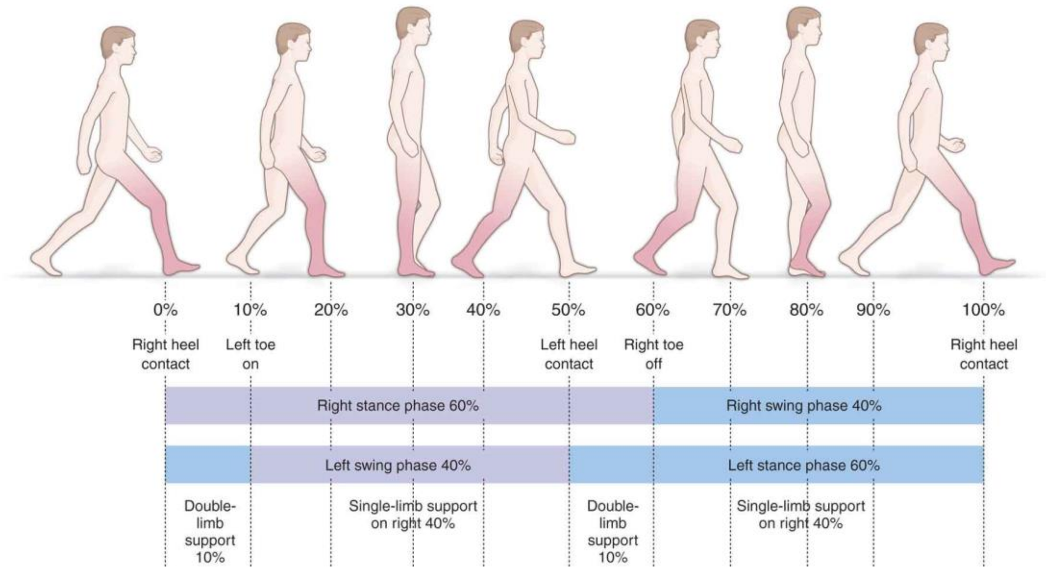

Figure 4. https://musculoskeletalkey.com/gait-and-posture-analysis/

The "Gait Parameter", reading

Gait analysis from T&T Medilogic has identified a few crucial human gait metrics that are helpful for actual evaluation. The distribution of the load under the foot forms a significant portion of the parameters. General factors like speed, step length, and stance phase are included in addition to them. A database of comparison values (Nom.) has been constructed from a set of test subjects with unobtrusive gait patterns for examination and interpretation. The relative location of each parameter in relation to the comparison group is displayed using color. Green denotes a near match to the comparison values, yellow denotes a little difference, and red denotes a significant departure. About 800 measurements from 164 test subjects were used to create the internal database, which removed the speed dependence of several metrics. The quantitative gait analysis's primary metric is speed. A person automatically selects the speed that best suits their locomotor capabilities. Therefore, a significant drop in walking speed is a clear sign of pathology. Many characteristics rely on speed, therefore comparisons utilizing those factors (such before-and-after care) are only valid at walking speeds that are comparable. Determining the relative speed has been beneficial (V_{rel}) taking into account the body height (L_0) of the patient: $V_{rel} = V/L_0$ in [1/s]. From one ground contact of the same foot to the next ground contact of the same foot, a whole gait cycle is formed; this is referred to as a double step. The length of a double step (L) is the distance that is traveled in a single double step. The relative double step length (Lrel), which also depends on body height, is defined as follows: L/L0 = Lrel. This variable is independent of the unit. A short double step length indicates an unstable stride. The reciprocal of the double step frequency, which has the unit min-1, is the double step duration (DSD). The two-footed position, as defined by %DSD, is when both feet are on the ground. An unstable gait is also indicated by a high value of these parameter. The proportion of DSD during which one leg is on the ground during the stance phase is computed for each leg independently. Patients who only have one side affected (because to an accident or a leg prosthesis, for example) typically have a shorter stance phase length on that side. The effective foot length is calculated as a percentage of the effective insole length using the average gait line. It is a measurement for the entire foot's roll. The variance in the gait line-s medial-lateral direction is known as its width, and is measured as a percentage of the insole's width. Thus, it serves as a gauge for how much the gait line deviates during single steps. Ankle and prosthesis gait injuries can result in an extremely narrow gait line. The same can be said for a gait issue indicated by a very broad gait line.

Measurements

Each subject's age, height, weight, and BMI were noted before to data collection. To establish a secure fixation, the Medilogic insoles were placed directly on the subject's feet while wearing athletic shoes. The same walking pace, cadence, and step length were chosen for each subject to provide a high level of standardization. To begin the test, a "GO" auditory signal was given. All measuring units began as soon as the subject took the first step. Each participant did 4 gait cycles (8 steps). Each participant crossed the walkway two or three times before data collection to become used to it.

Statistical analysis

Statistical analysis was performed via IBM SPSS Statistics 26 using Descriptive Statistics and Student's*t* test. The level of significance was set at 0.05.

Results

Table 1. Anthropometric measurements results

Subject ID	Age (years)	Body Mass (kg)	Height (cm)	BMI
ID L001251 (F)	19	58.3	169	20.4
ID L001250 (F)	19	61.9	160	24.2
ID L001232 (F)	20	53.2	153	22.7
ID L001233 (F)	21	67.6	177	21.6
ID L001237 (F)	20	48.8	164	18.1
ID L001236 (F)	27	56.7	154	23.9
ID L001234 (F)	20	51.6	161	19.9
ID L001235	30	52.3	151	22.9

(F)				
ID L001238 (M)	30	69.2	175	22.6
ID L001253 (M)	17	48.2	149	21.7
ID L001256 (F)	17	55.9	159	22.1
ID L001257 (F)	22	41	145	19.5
ID L001261 (M)	23	53.3	161	20.6
ID L001259 (F)	22	42.7	145	20.3
ID L001260 (F)	22	56.6	164	21
ID L001255 (M)	21	50.7	154	21.4
ID L001254 (F)	26	42.5	154	17.9
ID L001258 (M)	29	67.2	169	22
Mean	22.61	53.76	159.11	

Table 2. General gait Parameters 1

	Speed [km/h]	Rel. Speed [1/s]	Double Step Length [m]		Rel Double Step Length		Double Step Duration [s]		Two Stance DSD]	Leg [%
Subject ID	Is	Is	Is	Nom.	Is	Nom.	Is	Nom.	Is	Nom.
ID L001251 (F)	3.9	0.64	1.35	1.24	0.8	1	0.81	0.71	17.5	21.9
ID L001250 (F)	4.2	0.72	1.27	1.39	0.79	0.76	1.1	1.08	20.5	21
ID L001232 (F)	3.8	0.68	1.17	1.28	0.77	0.73	1.12	1.1	23	21.4
ID L001233 (F)	4.6	0.72	1.57	1.32	0.89	0.76	1.23	1.08	21.5	21
ID L001237 (F)	3.2	0.55	1.2	1.14	0.74	0.65	1.33	1.21	23.5	23.2
ID L001236 (F)	3.6	0.65	1.18	1.24	0.76	0.71	1.17	1.13	24	21.9
ID L001234 (F)	3.6	0.62	1.17	1.22	0.74	0.69	1.18	1.15	18	22.2
ID L001235 (F)	3.6	0.65	1.2	1.24	0.78	0.71	1.2	1.13	24.5	21.8

ID L001238 (M)	4.6	0.73	1.53	1.34	0.88	0.77	1.2	1.07	20	20.9
ID L001253 (M)	3.9	0.71	1.22	1.31	0.8	0.75	1.13	1.09	21	21.1
ID L001256 (F)	4	0.69	1.2	1.29	0.75	0.74	1.08	1.1	23.5	21.3
ID L001257 (F)	4.1	0.78	1.24	1.39	0.84	0.8	1.08	1.04	22	20.4
ID L001261 (M)	3.4	0.58	1.05	1.17	0.64	0.67	1.1	1.18	19	22.7
ID L001259 (F)	3.9	0.75	1.12	1.35	0.77	0.77	1.03	1.06	19	20.7
ID L001260 (F)	4.1	0.7	1.26	1.3	0.76	0.74	1.1	1.1	20.5	21.3
ID L001255 (M)	4.5	0.81	1.48	1.41	0.96	0.81	1.18	1.02	21	20.1
ID L001254 (F)	3.5	0.62	1.09	1.22	0.7	0.69	1.12	1.15	21.5	22.2
ID L001258 (M)	3.8	0.61	1.35	1.2	0.78	0.68	1.29	1.16	19	22.4
Mean	3.905	0.678	1.26	1.281	0.79	0.746	1.14	1.087	21.06	21.53
Standart Dev.	0.40	0.07	0.15	0.08	0.07	0.08	0.11	0.11	2.09	0.82

Table 3. General gait Parameters 1

	Stancephase Duration, Left [% DSD]		Effective Foot Length, Left [%]		Width of Gait Line, Left [%]		Stancephase Duration, right [% DSD]		Effective Foot Length, Right [%]		Width of Gait Line, right [%]	
Subject ID	Is	Nom.	Is	Nom.	Is	Nom.	Is	Nom.	Is	Nom.	Is	Nom.
ID L001251 (F)	58	61.2	80.1	69.7	6.3	3.8	59.5	61.2	73.4	69.7	7	3.8
ID L001250 (F)	60.5	60.7	73.4	69.7	3.1	3.8	60	60.7	71.8	69.7	4.3	3.8
ID L001232 (F)	62	60.9	65.1	69.7	5.9	3.8	61	60.9	57.5	69.7	7.9	3.8
ID L001233 (F)	60.5	60.7	66.8	69.7	5.4	3.8	61	60.7	65.9	69.7	9.9	3.8
ID	61.	61.	59.	69.	7.6	3.8	62	61.	60.	69.	5.3	3.8

L001237 (F)	5	9	8	7				9	3	7		
ID L001236 (F)	63	61.2	71	69.7	1.4	3.8	61	61.2	54.8	69.7	2	3.8
ID L001234 (F)	59.5	61.4	56.7	69.7	4.7	3.8	58.5	61.4	53.1	69.7	6.5	3.8
ID L001235 (F)	61.5	61.2	62.6	69.7	5.1	3.8	63	61.2	64.8	69.7	7.1	3.8
ID L001238 (M)	60.5	60.6	70.2	69.7	4.3	3.8	59.5	60.6	76.7	69.7	4.1	3.8
ID L001253 (M)	60	60.8	64.7	69.7	5.1	3.8	61	60.8	69.4	69.7	3.5	3.8
ID L001256 (F)	61.5	60.9	77.6	69.7	2.7	3.8	62	60.9	66.5	69.7	3.5	3.8
ID L001257 (F)	61.5	60.3	65.1	69.7	9.3	3.8	60.5	60.3	62.5	69.7	7.7	3.8
ID L001261 (M)	58	61.7	68	69.7	2.9	3.8	61	61.7	66.7	69.7	5.1	3.8
ID L001259 (F)	58	60.5	63.3	69.7	3.2	3.8	61	60.5	62.6	69.7	3.3	3.8
ID L001260 (F)	61	60.8	71.5	69.7	3.3	3.8	59.5	60.8	70.8	69.7	4.4	3.8
ID L001255 (M)	61	60.1	62.3	69.7	3	3.8	60	60.1	62.7	69.7	5.3	3.8
ID L001254 (F)	59.5	61.4	69.2	69.7	4	3.8	62	61.4	67.7	69.7	6.4	3.8
ID L001258 (M)	59.5	61.5	69.3	69.7	3.2	3.8	59.5	61.5	71.7	69.7	5	3.8
Mean	60.39	60.98	67.59	69.7	4.47	3.8	60.66	60.98	65.49	69.7	5.4611	3.8
Standart Dev.	1.43	0.48	5.95	0.00	1.94	0.00	1.15	0.48	6.42	0.00	1.98	0.00

T-Tests Results

Ten paired samples t-test were conducted, in order to compare values between “Is” and “Nom” values for each dependent variable (Table 4). These comparisons revealed statistically significant differences between “is” and “nom.” measurements for the following variables: “RelDoubleStepLength”, “DoubleStepDuration”, “EffectiveFootLengthRight” and “WidthOfGaitRight” ($p<0.005$). For the rest of the variables the differences between “is” and “nom” values were not statistically significant based on paired samples t-test results ($p>0.005$). Box-plot for “WidthOfGait” is presented in figure 5.

Table 4. Paired Samples Test results

Paired Samples Test

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	DoubleStepLength_Is DoubleStepLength_Nom.	--.02222	.13095	.03087	-.08734	.04290	-.720	17	.481
Pair 2	**RelDoubleStepLength_Is RelDoubleStepLength_Nom.**	**-.04000**	**.07623**	**.01797**	**.00209**	**.07791**	**2.226**	**17**	**.040**
Pair 3	**DoubleStepDuration_Is DoubleStepDuration_Nom.**	**-.04944**	**.06958**	**.01640**	**.01485**	**.08404**	**3.015**	**17**	**.008**
Pair 4	TwoFootedStance_Is TwoFootedStanced_Nom.	--.4722	2.2510	.5306	-1.5916	.6472	-.890	17	.386
Pair 5	StancephaseDurationLeft_Is StancephaseDurationLeft_Nom.	--.6000	1.5904	.3749	-1.3909	.1909	-1.601	17	.128
Pair 6	EffectiveFootLengthLeft_Is EffectiveFootLengthLeft_Nom.	--2.1056	5.9498	1.4024	-5.0643	.8532	-1.501	17	.152
Pair 7	WidthOfGaitLineLeft_Is WidthOfGaitLineLeft_Nom.	-.6722	1.9423	.4578	-.2937	1.6381	1.468	17	.160
Pair 8	StancephaseDuration_Right_Is StancephaseDurationRight_Nom.	-.3222 -	1.1533	.2718	-.8957	.2513	-1.185	17	.252
Pair 9	**EffectiveFootLengthRight_Is EffectiveFootLengthRight_Nom.**	**- -4.2056**	**6.4249**	**1.5144**	**- 7.4006**	**- 1.0105**	**-2.777**	**17**	**.013**

Pair 10	**WidthOfGaitRight_Is – WidthOfGateRight_Nom.**	**1.6611**	**1.9814**	**.4670**	**.6758**	**2.6465**	**3.557**	**17**	**.002**

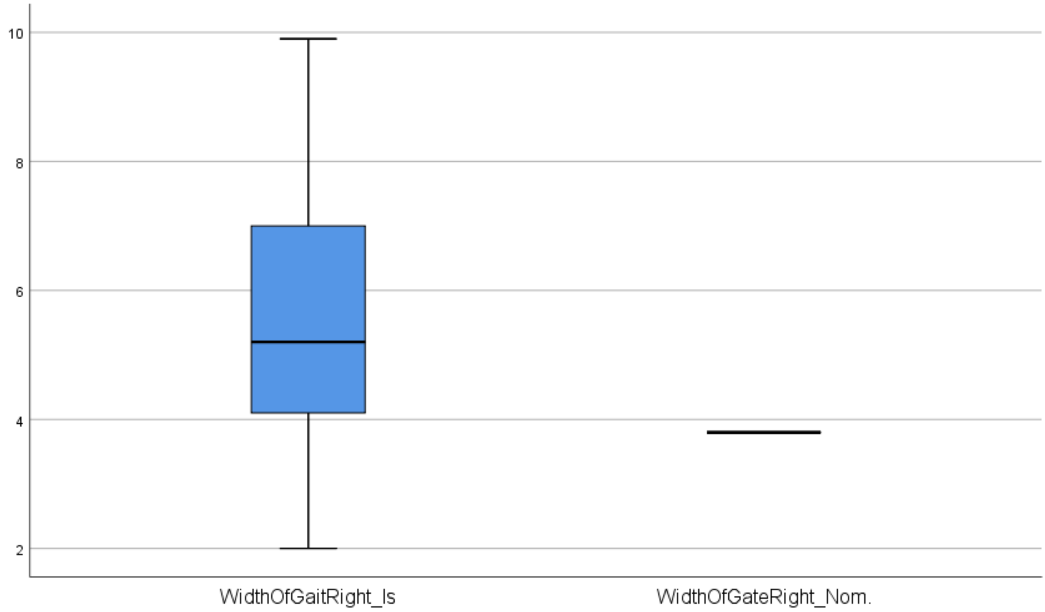

Figure 5. Box-plot for "WidthOfGait" distribution.

Discussion

The aim of the study was to assess the gait parameter in Albanian individuals with thalassemia. Based on the result of the "General Gait Parameters", the "Double Step Length" mean were 1.26[m] and compared with the "Nom." relative mean values that were 1.28[m] we have a diference of 0.2[m] which is an indication of an insecure gait. Nevertheless, mean results of "Double Step Duration [s]" parameter was 1.14[s] compared with the "Nom." relative mean values that were 1.09[s] resulting in a non significant difference 0.05[s]. In the "Two Footed Stance [%DSD]" parameter the mean results were 21.06 [%DSD] compared with "Nom." 21.53 [% DSD], indicating approximately 1[% DSD] which is not a high value to indicate a sign for an insecure gait (Table 2). Regarding the "Stancephase Duration of Left Foot [%DSD]" parameter, mean datas results values were 60.39[%DSD] compared with the "Nom." relative mean values that were 60.98[%DSD], which is not a significant difference to reveal any gait problem. Also "Stancephase Duration of Right Foot [%DSD]" parameter, mean datas results values were 60.66[%DSD] compared with the "Nom." relative mean values that were 60.88[%DSD], also demonstrates a non significant difference for any gait problem. The "Effective Foot Length, left [%]" parameter mean results [67.59%], reveals approximately a 2% difference compared with the relative "Nom." mean [69.7%]. Also, the same parameter for the left foot ("Effective Foot Length, left [%]") mean results [65.49%], reveals approximately a 3.5% difference compared with the relative “Nom.” mean [69.7%]. Both these parameters reveal a difference in the % of the average gait line. Continuing with the “Width of Gait Line, left foot [%]” parameter, results [4.47%] show a a minor difference [0.7%] compared with the relative “Nom.” mean [3.8%]. Also, the results of this parameter fort the right foot (“Width of Gait Line, right foot [%]”) show a 1.66% difference compared with the relative normative mean [3.8%] (Table 3). These comparisons revealed statistically significant differences between “is” and “nom.” measurements for the following variables: “Rel Double Step Length”, “Double Step Duration”, “Effective Foot Length Right” and “Width Of Gait Right” ($p<0.005$). These parameters reveal a difference in the % of the average gait line which is related to effective distribution in the insole length showing a specific indication of insecure gait most probably related to the mentioned problems associated to this specific category population has. Results for the rest of the variables shwed a not statistically significant difference.

Conclusions

To conclude, our findings showed that, ß-thalassemia patients, based on the results had specific indicatators revealing an insecure gait. Based on the result of the “General Gait Parameters”, we can say that gait problems are mostly related to the specific health related problem and side effects like, skeletal deformities and posture related problems, iron overload, high calcium levels related with periodic blood transfusions, inactivity associated with low muscle mass etc.

Reccomendations

Future studies should be conducted involving larger ß-thalassemia patients take into account the unique state of this category to better evaluate the gait problems also associated with general postural problems in static and dynamic phases. Clinicians’ health specialists and rehabilitation experts when planning B-Thal rehabilitation programs sholud use gait analysis exam as a regular health check-up.

Study Limitations

Some of this study limitations issues were the small sample size and also the lack of on physical activity intervention program in ordert to compare gait analysis data prior and after the intervention program. Also giving the specifics of the insoles and software usage and the specifities of this population category it was difficult to find normative datas to compare with.

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