Orginal Article

Investigation of Gait Characteristics and Factors Affecting Gait in Children with Atopic Dermatitis

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Abstract

Aim: Atopic dermatitis (AD) is a chronic inflammatory disease. This study aimed to investigate gait characteristics and possible factors affecting gait in children with AD using Win-Track gait analysis.

Materials and Methods: A total of 100 children, including 50 patients with AD, were diagnosed according to Hanifin Rajka criteria and 50 controls aged 7-16 years in this study. The Scoring of Atopic Dermatitis (SCORAD) index was calculated, and the body mass index (BMI) was determined. Serum immunoglobulin E (IgE), vitamin B12, and vitamin D levels were examined, and Win-Track gait analysis was performed.

Results: Among the gait parameters, the median (minimum-maximum) maximum foot pressure on the left was 625.00 (412-872) in patients and 686.50 (466-890) in the controls ($P = 0.006$). The median step length on the right was 527.00 (258-640) in patients and 555.00 (422-672) in the controls ($P = 0.012$). Angle on the right was higher on the right side 7-11 age median 3.67 (1.49-11.31) compared to the 12-16 age median 1.51 (0-3.5) in those with moderate and severe SCORAD index ($P < 0.05$).

Conclusion: Low foot pressure on the non-dominant limb side and short stride length on the dominant limb side were determined in patients with AD a gait characteristic different from those of controls. Gait parameters were found to be affected by increased disease severity, BMI, serum IgE, and vitamin D levels in patients with AD.

Keywords: Atopic dermatitis, gait, SCORAD, win-track

Introduction

Atopic dermatitis (AD) is a chronic inflammatory disease characterized by erythematous, squamous, and itchy skin lesions.[1] AD has been defined not only as a collection of skin manifestations but also as a pattern of reaction to allergens.[2] It has been shown that children and adolescents with AD have longer eyelashes than non-atopic controls and that long eyelashes may be a phenotypic feature of allergic disease.[3] Allergic comorbidities, such as AD asthma and allergic rhinitis, as well as cutaneous bacterial/viral diseases, ichthyosis vulgaris, keratoconjunctivitis, cataract, autoimmune diseases, such as alopecia areata/vitiligo, obesity, metabolic syndrome, cardiovascular and gastrointestinal immune-mediated disorders, anemia and lymphoma. Mental disorders, insomnia, hyperactivity, autism, speech disorders, and anxiety/depression have been reported in patients with AD.[4-6] Decreased bone mineral density has been found in adult patients with moderate to severe AD and has been attributed to the long-term use of topical corticosteroids or the chronic inflammatory nature of the disease.[7] Decreased bone mineral density has also been found in malnourished children

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with AD.[8] Garg et al.[9] also reported that bone fractures and joint injuries were more common in adult AD patients. Especially in children with AD, the risk of accidents is higher. These conditions are believed to be associated with disease severity and uncontrolled disease.[10]

Gait is the most important human skill, and loss of the ability to walk is recognized as a loss of quality of life.[11] Normal gait requires precise control of limb movements, posture, and muscle tone, which is an extraordinarily complex process involving the entire nervous system.[12] Assessment of gait parameters can provide insight into general health or help to identify an underlying pathology.[13] In this study, the demographic, clinical, and laboratory parameters of children with AD, gait characteristics, and possible factors that may affect gait were examined using the Win-Track gait platform.

Materials and Methods

In this study, the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation and the Helsinki Declaration. This study was conducted in the clinics of Dermatology, Physical Medicine and Rehabilitation, and Pediatric Neurology after obtaining approval from the Fırat University Local Ethics Committee (approval number: E-97132852-050.01.04-7053, date: 06.01.2021). The parents of all participants were informed, and a consent form was filled out and approval was obtained. Fifty patients between the ages of 7-16 with AD were diagnosed according to Hanifin Rajka criteria and did not have any systemic disease and/or did not use systemic drugs and 50 controls a total of 100 participants were included in the study. Body mass index (BMI) was determined according to pediatric reference of percentile values (< 5 = weak, 5-85 = normal, 86-95 = overweight, > 95 = obese).[14] The Scoring of Atopic Dermatitis (SCORAD) Index was calculated (< 25 = mild, 25-50 = moderate, > 50 = severe).[15] Participants with lower extremity anomalies or dermatologic lesions such as viral warts, calluses, and ulcers on the soles of the feet and pes planus, patients with a diagnosis of neurological disease or rheumatologic diseases, and patients using any systemic medication that may affect gait were excluded from the study.

Gait analysis of all participants was performed on the Win-Track gait platform (MEDICAPTEURS Technology, France).[16] During the study, participants were asked to take 3 steps forward outside the platform by following the 3-step protocol. At the end of these steps, the point at which the third heel touched was marked, and this point was accepted as the starting point. Participants were asked to look forward and gait at a comfortable pace on the platform, be full, and gait after a period of rest to avoid the effects of hunger and fatigue.

Serum immunoglobulin E (IgE), vitamin B12, and vitamin D levels examinated. For serum total IgE (IU/mL) (< 90 = normal for 7-9 years old; < 200 = normal for 10-15 years old; < 100 = normal for 16 years old) and vitamin B12 (pg/mL) (174-878) levels, the reference values classified according to age by the hospital were taken into consideration. The literature was taken into consideration in determining reference intervals for serum vitamin D (µg/L) levels (< 5 is severe deficiency, 5-15 is mild-moderate deficiency, 16-20 is insufficient, 21-100 is sufficient).[17]

Statistical analysis

The Statistical Package for Social Sciences (SPSS Inc., Chicago, IL) 22 package program was used for the analyses. Descriptive data are presented as (n) and (%) values for categorical data and mean ± standard deviation and median (minimum-maximum) values for continuous data. The chi-square test was used to compare categorical variables between groups. The Shapiro-Wilk Goodness of Fit test and the Kolmogorow-Smirnov test were used to test whether the data fit the normal distribution. Because the data did not fit the normal distribution, the Mann-Whitney U test was used for the comparison of two groups, and the Kruskal-Wallis test was used for the comparison of more than two groups.

Results

The mean age was 10.80±2.9 years in the patients and 11.08±2.6 years in controls. Demographic characteristics, clinical findings, SCORAD index, BMI, IgE, vitamin D, vitamin B12 categories, dominant extremity characteristics of the patient and control groups are presented in Table 1. Vitamin B12 values were found to be statistically significantly higher in the patient group (388.00±119.52 than in the control group (304.46±92.62) ($P < 0.05$). There was no significant differences BMI, and other laboratory parameters ($P > 0.05$). The odds ratios (OR) were 2.92 for IgE and 1.6 for vitamin D in patients and controls. In the patients, the OR for the SCORAD index and age category were 1.12, for SCORAD index and IgE category was 0.62, and for SCORAD index and vitamin D category was 1.90.

Among the gait parameters, the median (minimum-maximum) maximum foot pressure on the left was 625.00 (412-872) in patients and 686.50 (466-890) in the controls ($P = 0.006$). The median step length on the right was 527.00 (258-640) in patients and 555.00 (422-672) in the controls ($P = 0.012$). The median (minimum-maximum) angle on the right was 3.26 (0-11.31), in the patients with moderate and severe SCORAD index and 6.34 (0-45) in patients with mild SCORAD index ($P < 0.05$). There was no difference between gender and the

gait parameters in the patients ($P > 0.05$). The gait parameters according to age, BMI, and vitamin D categories in the patients are presented in Tables 2-4, respectively. 3rd step mean pressure was lower in the patients with normal IgE [718 (457-1030)] than in the patients with high IgE [798 (524-1016)], and step duration on the right was higher in the patients with normal IgE [600 (450-800)] than in the patients with high IgE [550 (270-690)] ($P < 0.05$). The total and forefoot areas on the right and 2nd step average pressure were lower in those with normal BMI compared with those with overweight and obesity in those with mild SCORAD index ($P < 0.05$).

In patients with mild SCORAD index and high IgE, 3rd step average pressure was higher and step duration on the right side was lower than that in patients with normal IgE ($P < 0.05$). No difference was detected in the IgE category between the groups with moderate and severe SCORAD index ($P > 0.05$). The gait parameters according to the SCORAD and vitamin D categories of the patients are presented in Table 5.

Discussion

The dominant limb was recorded as the right limb in the majority of patients with AD and controls in this study. Among the gait parameters, the maximum foot pressure and stride length were lower on the left and right in patients with AD. It was thought that low foot pressure on the non-dominant limb side and short stride length on the dominant limb side in patients with AD may be gait characteristics that differ from controls. The angle was lower on the right side in patients with moderate and severe SCORAD index. The increased disease severity may have contributed to the decreased angle on the dominant limb side. Moreover, the angle was lower on the right side in patients aged 12 years with moderate and severe SCORAD index. When the SCORAD index and age were evaluated together in the patients, it was thought that the effect of age on the gait parameters was independent of the SCORAD index.

Similar pathophysiologic mechanisms are believed between obesity and AD. Skin-barrier dysfunction and microbiota alterations in AD are also associated with obesity.[18]

Table 1. Demographic characteristics, clinical findings, SCORAD index, BMI, IgE, vitamin D, vitamin B12 categories, dominant extremity characteristics of the patient and control groups

Parameter		Group: Patient (n, %)	Group: Control (n, %)
Gender	Female	24 (48)	17 (34)
	Male	26 (52)	33 (66)
The age category	7-11	29 (58)	29 (58)
	12-16	21 (42)	21 (42)
Localization of dermatological lesions	Head-neck	43 (86)	
	Body	12 (24)	
	Upper extremity	20 (40)	
	Lower extremity	27 (54)	
	Genitalia	1 (2)	
	Nail	13 (26)	
Dermatological findings	Erythema	15 (30)	
	Edema/papule	7 (14)	
	Wet/crust	4 (8)	
	Excoriation	18 (36)	
	Lichenification	8 (16)	
	Xerosis	32 /64)	
	Dennie Morgan's lines	33 (66)	
	Orbital darkening	43 (86)	
SCORAD* index	Light	35 (70)	
	Moderate-severe	15 (30)	
BMI† category	Underweight	6 (3)	4 (8)
	Normal	34 (68)	33 (66)
	Overweight and obese	10 (20)	13 (26)
IgE‡ category	Normal	26 (52)	38 (76)
	High	24 (48)	12 (24)
The vitamin D category	Normal	32 (64)	37 (74)
	Mild/medium low and low	18 (36)	13 (26)
The vitamin B12 category	Normal	46 (92)	44 (88)
	Low	4 (8)	6 (12)
Dominant extremity	Right	46 (92)	45 (90)
	Left	4 (8)	5 (10)

*Scoring of atopic dermatitis, BMI†: Body mass index, IgE‡: Immunoglobulin E, SCORAD: The Scoring of Atopic Dermatitis

Table 2. Gait parameters according to the age group category in the patients

Parameter	Age category (50): 7-11 (29) Median (minimum-maximum)	Age category (50): 12-16 (21) Median (minimum-maximum)	*P* value
Body weight (kg)	32.00 (18-67)	49.00 (26-108)	**0.000**
Body weight distribution right (kg)	16.50 (9-31)	23.50 (14-54)	**0.000**
Body weight distribution left (kg)	16.50 (9-36)	25.50 (12-54)	**0.000**
Gait cycle length to the right (mm)	1015.00 (0-1242)	1046.00 (0-1265)	0.153
Gait cycle length left sol (mm)	1039.00 (765-1242)	1152.00 (0-1265)	**0.002**

Table 2. Continued

Parameter	Age category (50)		*P* value
	7-11 (29)	12-16 (21)	
	Median (minimum-maximum)		
Gait cycle duration at right (ms)	0.00 (0-1440)	0.00 (0-1350)	0.708
Gait cycle duration left (ms)	1010.00 (0-450)	0.00 (0-0)	0.214
Total right area (cm^2)	54.00 (34-102)	71.00 (37-121)	**0.001**
Total area left (cm^2)	57.00 (30-101)	77.00 (35-126)	**0.001**
Forefoot area to the right (cm^2)	25.50 (13-49)	37.00 (15-61)	**0.040**
Left forefoot area (cm^2)	26.00 (12-51)	39.00 (11-60)	**0.005**
Hindfoot area to the right (cm^2)	26.50 (17-53)	37.00 (18-74)	**0.001**
Left hindfoot area (cm^2)	29.00 (12-60)	37.00 (18-74)	**0.006**
1st step area (cm^2)	91.00 (41-130)	114.00 (65-195)	**0.005**
2nd step area (cm^2)	88.50 (54-147)	118.00 (40-197)	**0.000**
3rd step area (cm^2)	89.00 (59-142)	117.00 (68-153)	**0.000**
Maximum right pressure (g/cm^2)	631.50 (412-930)	704.50 (493-1157)	**0.013**
Maximum pressure left (g/cm^2)	634.00 (412-890)	668.50 (475-872)	**0.018**
1st step maximum pressure (g/cm^2)	1453.00 (1110-1962)	1558.00 (1069-2605)	**0.003**
2nd step maximum pressure (g/cm^2)	1364.50 (854-1846)	1534.50 (1143-2239)	**0.002**
3rd step maximum pressure (g/cm^2)	1339.50 (845-1846)	1481.50 (1089-2792)	**0.008**
Average right pressure (g/cm^2)	295.50 (225-419)	33.50 (240-469)	**0.012**
Average pressure left (g/cm^2)	306.50 (206-431)	341.00 (248-454)	**0.006**
1st step average pressure (g/cm^2)	809.00 (528-981)	840.50 (606-1170)	**0.024**
2nd step average pressure (g/cm^2)	758.50 (465-993)	831.50 (653-1098)	**0.003**
3rd step average pressure (g/cm^2)	731.50 (457-953)	779.00 (599-1030)	**0.026**
Step length right (mm)	519.00 (258-640)	578.00 (336-672)	**0.003**
Step length left (mm)	525.00 (320-656)	578.00 (305-640)	**0.001**
Step duration right (ms)	530.00 (270-700)	595.00 (340-800)	**0.017**
Left step duration (ms)	530.00 (220-740)	580.00 (200-790)	**0.001**
Single-stance duration right (ms)	0.00 (0-500)	0.00 (0-450)	0.440
Single-stance duration left (ms)	0.00 (0-450)	0.00 (0-0)	**0.047**
Double-stance duration right (ms)	0.00 (0-320)	0.00 (0-360)	0.581
Double-stance duration left (ms)	200.00 (0-340)	240.00 (0.450)	0.278
Swing duration right (ms)	1165.00 (980-1580)	1280.00 (820-1490)	**0.003**
Swing duration left sol (ms)	1150.00 (890-1470)	1265.00 (970-1750)	**0.000**

Table 3. Gait parameters according to the BMI category in the patients

Parameter	BMI category (50)			*P* value
	Underweight (6)	Normal (34)	Overweight and obese (10)	
	Median (minimum-maximum)			
Body weight (kg)	29.00 (21-50)	37.00 (18-67)	49 (25-108)	0.141
Body weight distribution right (kg)	15.50 (10-23)	19.00 (9-35)	25.00 (12.54)	0.143
Body weight distribution left (kg)	14.00 (10-72)	20.00 (9-36)	25.00 (13.54)	0.164
Gait cycle length to the right (mm)	1027.00 (0-1218)	1015.00 (0-1265)	1015.00 (0-1242)	0.171
Gait cycle length left sol (mm)	1054.00 (883-1218)	1078.00 (0-1265)	1101.00 (867-1242)	0.345
Gait cycle duration at right (ms)	0.00 (0-1160)	0.00 (0-1440)	0.00 (0-1150)	0.553
Gait cycle duration left (ms)	1125.00 (0-1300)	1020.00 (0-1360)	1010.00 (0-1550)	0.580
Total right area (cm^2)	44.50 (35-72)[a]	61.00 (34-101)[a]	71.00 (49-121)[b]	**0.019**
Total area left (cm^2)	42.50 (30-77)	61.00 (34-102)	79.00 (47-126)	0.064

Table 3. Continued

Parameter	BMI category (50)			*P* value
	Underweight (6)	Normal (34)	Overweight and obese (10)	
	Median (minimum-maximum)			
Forefoot area to the right (cm^2)	19.00 (15-44)[a]	29.00 (13-61)[a]	36.00 (18-59)[b]	**0.030**
Left forefoot area (cm^2)	20.50 (11.46)	31.00 (12-59)	34.00 (20-60)	0.183
Hindfoot area to the right (cm^2)	26.00 (17-40)[a,b]	29.00 (18-52)[a]	40.00 (23-77)[b]	**0.042**
Left hindfoot area (cm^2)	27.00 (17-42)[a,b]	32.00 (12-61)[a]	43.00 (27-74)[b]	**0.049**
1st step area (cm^2)	34.50 (63-112)	96.00 (41-149)	112.00 (69-195)	0.070
2nd step area (cm^2)	94. (40-121)50	93.00 (59-138)	113.00 (70-197)	0.131
3rd step area (cm^2)	93.00 (59-117)[a,b]	93.00 (60-145)[a]	113.00 (71-153)[b]	**0.044**
Maximum right pressure (g/cm^2)	669.00 (561-865)	650.00 (412-1001)	719.00 (491-1157)	0.185
Maximum pressure left (g/cm^2)	731.50 (587-848)[a]	633.00 (412-880)[b]	651.00 (509-890)[a,b]	**0.023**
1st step maximum pressure (g/cm^2)	1461.00 (1069-1719)	1501.00 (1110-2605)	1514.00 (1148-2001)	0.507
2nd step maximum pressure (g/cm^2)	1364.50 (11.90-1652)[a,b]	1439.00 (854-2239)[a]	1535.00 (1175-2228)[b]	**0.024**
3rd step maximum pressure (g/cm^2)	1353.00 (1123-1648)	1411.00 (845-2792)	1438.00 (965-1886)	0.288
Average right pressure (g/cm^2)	317.00 (280-375)	300.00 8225-469)	317.00 (240-451)	0.327
Average pressure left (g/cm^2)	340.50 (251-391)	306.00 (206-421)	325.00 (248-454)	0.073
1st step average pressure (g/cm^2)	778.00 (606-980)	819.00 (528-998)	835.00 (594-1107)	0.326
2nd step average pressure (g/cm^2)	774.00 (617-889)[a,b]	773.00 (465-999)[a]	849.00 (661-1098)[b]	**0.041**
3rd step average pressure (g/cm^2)	692.00 (553-885)	749.00 (457-1030)	799.00 (591-1016)	0.167
Step length right (mm)	539.00 (336-617)	539.00 (258-672)	555.00 (437-640)	0.358
Step length left (mm)	554.50 (461-633)	539.00 (305-640)	539.00 (422-656)	0.080
Step duration right (ms)	570.00 (340-670)	560.00 (270-740)	580.00 (430-800)	0.787
Left step duration (ms)	570.00 (500-630)	560.00 (200-740)	540.00 (330-790)	0.732
Single-stance duration right (ms)	0.00 (0-440)	0.00 (0-500)	0.00 (0-390)	0.506
Single-stance duration left (ms)	0.00 (0-0)	0.00 (0-450)	0.00 (0-430)	0.686
Double-stance duration right (ms)	0.00 (0-260)	0.00 (0-360)	0.00 (0-260)	0.420
Double-stance duration left (ms)	215.00 (0-300)	200.00 (0.410)	250.00 (0-450)	0.403
Swing duration right (ms)	1245.00 (820-1370)	1210.00 (990-1580)	1220.00 (980-1360)	0.749
Swing duration left sol (ms)	1255.00 (1000-1430)	1190.00 (890-1550)	1230.00 (940-1750)	0.610

There was a significant difference between groups that did not have the same letter ($p<0.05$). BMI: Body mass index

Table 4. Gait parameters according to the vitamin D category in the patients

Parameter	Vitamin D category (n)		*P* value
	Mild/moderate low and low (18)	Normal (32)	
	Median (minimum-maximum)		
Body weight (kg)	42.00 (25-108)	36.00 (18-67)	**0.019**
Body weight distribution right (kg)	21.50 (13-54)	17.00 (9-31)	**0.012**
Body weight distribution left (kg)	21.00 (11-54)	18.00 (9-36)	**0.044**
Gait cycle length to the right (mm)	1027.00 (0-1218)	1023.00 (0-1211)	0.976
Gait cycle length left sol (mm)	1039.00 (0-1218)	1070.00 (765-1203)	0.848
Gait cycle duration at right (ms)	420.00 (0-1250)	0.00 (0-1440)	0.636
Gait cycle duration left (ms)	1030.00 (0-1550)	1020.00 (0-1300)	0.660
Total right area (cm^2)	71.00 (37-121)	58.00 (34-104)	**0.033**
Total area left (cm^2)	70.50 (35-126)	59.50 (34-102)	**0.049**
Forefoot area to the right (cm^2)	37.00 (14-61)	28.50 (13-59)	0.182
Left forefoot area (cm^2)	35.00 (12-57)	30.00 (11-60)	**0.047**
Hindfoot area to the right (cm^2)	35.00 (21-77)	27.00 (20-53)	**0.027**

Table 4. Continued

Parameter	Vitamin D category (n)		
	Mild/moderate low and low (18)	Normal (32)	
	Median (minimum-maximum)		*P* value
Left hindfoot area (cm^2)	37.00 (18-74)	29.50 (12-61)	0.108
1st step area (cm^2)	105.50 (41-195)	95.50 (61-139)	0.179
2nd step area (cm^2)	112.50 (40-197)	96.00 (65-147)	0.066
3rd step area (cm^2)	107.50 (60-153)	92.50 (60-137)	0.195
Maximum right pressure (g/cm^2)	706.50 (533-1157)	615.00 (412-897)	**0.024**
Maximum pressure left (g/cm^2)	644.00 (452-872)	613.00 (412-869)	0.599
1st step maximum pressure (g/cm^2)	1525.00 (1069-2120)	1434.00 (1110-1861)	0.157
2nd step maximum pressure (g/cm^2)	1530.00 (1186-2228)	1392.00 (854-1731)	0.020
3rd step maximum pressure (g/cm^2)	1477.50 (1089-1886)	1379.00 (845-1846)	0.115
Average right pressure (g/cm^2)	332.50 (237-469)	286.50 (240-435)	**0.046**
Average pressure left (g/cm^2)	313.00 (255-426)	301.50 (206-454)	0.182
1st step average pressure (g/cm^2)	828.50 (606-1107)	791.50 (528-992)	0.051
2nd step average pressure (g/cm^2)	786.50 (681-1098)	744.00 (465-957)	**0.010**
3rd step average pressure (g/cm^2)	785.00 (633-1030)	718.00 (457-906)	**0.010**
Step length right (mm)	519.00 (258-640)	535.00 (398-617)	0.895
Step length left (mm)	554.50 (390-633)	535.00 (320-633)	0.992
Step duration right (ms)	575.00 (270-800)	570.00 (370-700)	0.472
Left step duration (ms)	570.00 (220-750)	540.00 (420-740)	0.054
Single-stance duration right (ms)	0.00 (0-360)	0.00 (0-500)	0.591
Single-stance duration left (ms)	0.00 (0-450)	0.00 (0-430)	0.244
Double-stance duration right (ms)	0.00 (0-300)	0.00 (0-320)	0.747
Double-stance duration left (ms)	230.00 (0-450)	210.00 (0-340)	0.273
Swing duration right (ms)	1255.00 (820-1330)	1230.00 (1000-1580)	0.856
Swing duration left sol (ms)	1210.00 (890-1750)	1190.00 (1000-1470)	0.332

Table 5. Gait parameters according to the SCORAD and vitamin D categories in the patients

	SCORAD categories (n)					
	Mild (35)			Moderate-severe (15)		
Vitamin D category (n)	Mild/moderate low and low (11)	Normal (24)		Mild/moderate low and low (7)	Normal (8)	
Parameter	Median (minimum-maximum)		*P* value	Median (minimum-maximum)		*P* value
Body weight (kg)	43.00 (26-108)	38.00 (22-67)	0.061	41.00 (25-87)	31.00 (18-45)	0152
Body weight distribution right (kg)	23.00 (14-54)	17.00 (9-31)	**0.022**	20.00 (13-45)	17.50 (9-23)	0.232
Body weight distribution left (kg)	21.00 (12-54)	20.50 (10-36)	0.224	21.00 (11-42)	13.50 (9-22)	0.072
Gait cycle length to the right (mm)	1007.00 (0-1218)	1027.00 (0-1211)	0.903	1054.00 (789-1078)	949.00 (0-1195)	0.955
Gait cycle length left sol (mm)	1039.00 (883-1218)	1082.00 (804-1203)	0.875	1039.00 (0-1218)	1035.00 (765-1164)	0.867
Gait cycle duration at right (ms)	840.00 (0-1190)	0.00 (0-1440)	0.563	0.00 (0-1250)	485.00 (0-1290)	1.000
Gait cycle duration left (ms)	960.00 (0-1550)	1015.00 (0-1330)	0.958	1090.00 (0-1360)	1105.00 (0-1290)	0.613
Total right area (cm^2)	71.00 (37-121)	60.00 (34-104)	0.092	71.00 (40-109)	53.50 (36-85)	0.232
Total area left (cm^2)	68.00 (35-126)	61.00 (38-102)	0.163	71.00 (37-113)	54.50 (34-76)	0.121
Forefoot area to the right (cm^2)	30.00 (16-61)	28.00 (13-59)	0.316	37.00 (14-52)	31.00 (16-46)	0.463
Left forefoot area (cm^2)	36.00 (16-57)	30.00 (13-60)	0.163	34.00 (12-55)	28.50 (11-39)	0.121
Hindfoot area to the right (cm^2)	40.00 (21-77)	27.50 (21-53)	0.052	35.00 (24-67)	26.50 (20-41)	0.232
Left hindfoot area (cm^2)	37.00 (18-74)	31.50 (20-61)	0.451	37.00 (25-60)	26.50 (12-37)	**0.029**
1st step area (cm^2)	104.00 (41-195)	101.00 (66-139)	0.875	120.00 (68-177)	88.00 (61-99)	**0.040**

Table 5. Continued

	SCORAD categories (n)					
	Mild (35)			Moderate-severe (15)		
Vitamin D category (n)	Mild/moderate low and low (11)	Normal (24)		Mild/moderate low and low (7)	Normal (8)	
Parameter	Median (minimum-maximum)		*P* value	Median (minimum-maximum)		*P* value
2nd step area (cm^2)	119.00 (40-197)	103.50 (70-147)	0.107	97.00 (72-164)	89.50 (65-115)	0.336
3rd step area (cm^2)	115.00 (68-153)	96.50 (63-137)	0.211	93.00 (60-132)	89.00 (60-110)	0.397
Maximum right pressure (g/cm^2)	725.00 (562-1157)	615.00 (491-897)	**0.012**	611.00 (533-1022)	629.50 (412-865)	0.613
Maximum pressure left (g/cm^2)	662.00 (452-872)	630.50 (509-869)	0.430	562.00 (489-802)	569.50 (412-841)	0.867
1st step maximum pressure (g/cm^2)	1501.00 (1069-1974)	1420.50 (1110-1861)	0.334	1570.00 (1250-2120)	1591.50 (1111-1718)	0.613
2nd step maximum pressure (g/cm^2)	1526.00 (1298-2030)	1402.00 (1025-1731)	0.072	1592.00 (1186-2228)	1382.00 (854-1650)	0.281
3rd step maximum pressure (g/cm^2)	1491.00 (1089-1886)	1330.00 (901-1648)	0.123	1452.00 (1219-1721)	1449.00 (845-1846)	0.779
Average right pressure (g/cm^2)	333.00 (237-469)	287.00 (240-435)	0.047	318.00 (247-417)	279.00 (240-368)	0.463
Average pressure left (g/cm^2)	341.00 (255-426)	306.50 (248-454)	0.186	299.00 (259-415)	286.00 (206-386)	0.463
1st step average pressure (g/cm^2)	817.00 (606-1107)	771.50 (594-992)	0.115	835.00 (724-970)	818.00 (528-951)	0.463
2nd step average pressure (g/cm^2)	778.00 (734-1098)	756.50 (583-957)	0.056	790.00 (681-971)	717.00 (465-838)	0.072
3rd step average pressure (g/cm^2)	799.00 (633-1016)	718.00 (524-906)	**0.040**	771.00 (644-1030)	696.00 (457-810)	0.152
Step length right (mm)	531.00 (258-601)	539.00 (398-617)	0.766	508.00 (398-640)	500.00 (406-562)	0.779
Step length left (mm)	547.00 (422-633)	535.00 (461-633)	1.000	562.00 (390-578)	535.00 (320-633)	0.613
Step duration right (ms)	560.00 (270-800)	575.00 (370-700)	0.875	610.00 (490-690)	545.00 (450-660)	0.232
Left step duration (ms)	570.00 (220-750)	540.00 (420-740)	0.099	580.00 (520-700)	585.00 (490-630)	0.281
Single-stance duration right (ms)	0.00 (0-360)	0.00 (0-380)	0.847	0.00 (0-0)	0.00 (0-500)	0.463
Single-stance duration left (ms)	0.00 (0-450)	0.00 (0-430)	0.636	0.00 (0-420)	0.00 (0-0)	0.694
Double-stance duration right (ms)	0.00 (0-300)	0.00 (0-320)	0.766	0.00 (0-260)	80.00 (0-250)	0.867
Double-stance duration left (ms)	230.00 (0-450)	200.00 (0-300)	0.472	230.00 (0-410)	210.00 (0-340)	0.613
Swing duration right (ms)	1230.00 (820-1300)	1235.00 (1000-1580)	0.563	1270.00 (1110-1330)	1190.00 (1070-1360)	0.463
Swing duration left sol (ms)	1210.00 (890-1750)	1175.00 (1000-1430)	0.662	1210.00 (1110-1550)	1240.00 (1070-1470)	0.336

SCORAD: The Scoring of Atopic Dermatitis

In a meta-analysis, obesity and AD were found to be related in most studies. A positive association has been reported between AD and obesity in childhood.[19] Among the factors affecting gait characteristics, BMI and weight have been reported to be effective in addition to physical diseases[20] and obese individuals have higher risks in terms of gait.[21] A previous study showed a positive correlation between BMI and foot pressure distribution.[22] In another study, gait parameters such as foot area and maximum pressure were higher in overweight and obese children, and it was reported that obesity in childhood could not be compensated by the musculoskeletal system.[23] In this study, some of the gait parameters of patients with AD were affected by changes in BMI. Some of the gait parameters of patients with mild SCORAD index and normal BMI changed. Gait parameters and BMI could not be evaluated in the patients with moderate and severe SCORAD index because there was one underweight and one overweight and obese patient each. Therefore, it could not be clearly interpreted whether BMI would have a synergistic effect on gait parameters increases with disease severity.

In a meta-analysis, serum vitamin D levels in patients with AD in all age groups, but especially in pediatric patients with AD, were found to be lower than in the controls.[24] In another study, the relationship between vitamin D deficiency and disease severity scores such as SCORAD index and eczema area and severity index, in patients with AD was examined, and it was reported that low serum vitamin D level is a risk factor for disease severity, especially in children, and vitamin D supplementation provides a significant reduction in AD severity.[25] In this study, there was no difference in serum vitamin D levels between patients with AD and controls, and vitamin D was categorically low in 36% of patients with AD and 26% of controls. However, according to the OR values, low vitamin D levels appeared to increase both the likelihood and severity of the disease.

Morphological changes such as type 2 muscle fiber atrophy, gap formation between fibers, fat and glycogen infiltration, and fibrosis have been reported in vitamin D deficiency.[26] It has also been found to interact in a non-genomic manner with vitamin D receptors in muscle cells, thereby improving muscle

contraction function.[27] In a case report on the relationship between gait and vitamin D in patients with AD, osteomalacia was detected in a 34-year-old female patient who had avoided ultraviolet exposure and dietary restriction for 8 years because of AD, upon the appearance of bone pain, muscle weakness, and gait disturbance.[28] In the present case, gait disturbance appeared to have occurred as a complication of the behavior and eating habits of the patient with AD. The findings of this study suggest that serum vitamin D levels alter gait parameters in patients with AD.

In this study, there was no significant difference in serum IgE levels between patients with AD and controls. However, categorically, serum IgE levels were found to be elevated in 48% of patients with AD, and according to the calculated OR, elevated serum IgE levels were interpreted as increasing the risk of AD. These findings do not seem to increase the SCORAD index. Therefore, serum IgE levels may affect gait parameters independently of disease severity.

Vitamin B12 deficiency or excess is associated with many dermatologic diseases, such as vitiligo, aphthous stomatitis, AD, and acne. Cobalt is a component of vitamin B12 that can cause cobalt sensitization. Allergic reactions due to vitamin B12 injections have been reported.[29] A previous study reported an increased prevalence of AD in infants born to mothers with high folate and vitamin B12 levels during pregnancy.[30] In a patient with AD, vitamin B12 levels were found to be associated with AD severity over a 3-year follow-up period, and a decrease in disease severity was observed with vitamin B12 supplementation.[31] In another study, growth and development were slowed in pediatric patients with AD who underwent food restriction, including vitamin B12, but this did not affect disease severity.[32] In this study, vitamin B12 levels were higher in patients with AD. The findings indicated that there is a conflicting relationship between AD and vitamin B12 levels.

Study limitations

Since the study participants were not asked about their intake of food supplements containing vitamin B12, a clear interpretation could not be made. This is a limitation of the study.

Conclusion

In this study, low foot pressure on the non-dominant limb side and short stride length on the dominant limb side in children with AD may be gait characteristics that differ from controls. The increased disease severity may have contributed to the decreased angle on the dominant limb side. Gait parameters were found to be affected by increased BMI, serum IgE levels, and serum vitamin D levels in children with AD.

Footnote

Ethics Committee Approval: This study was conducted in the clinics of Dermatology, Physical Medicine and Rehabilitation, and Pediatric Neurology after obtaining approval from the Fırat University Local Ethics Committee (approval number: E-97132852-050.01.04-7053, date: 06.01.2021).

Informed Consent: The parents of all participants were informed, and a consent form was filled out and approval was obtained.

Authorship Contributions

Concept: B.D., G.A., S.K., D.Ç., Design: B.D., G.A., S.K., D.Ç., Data Collection or Processing: F.S., G.A., S.K., Analysis or Interpretation: B.D., G.A., S.K., Y.G., Writing: F.S., B.D.

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