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ORIGINAL ARTICLE

Kanser tanılı çocuklarla normal gelişen çocukların tek ve çift görev yürüyüş parametrelerinin karşılaştırılması

Comparison of single-and dual-task gait parameters of children with cancer and typically developing children

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Öz

Amaç: Bu çalışma, kanser tanılı çocuklar ile normal gelişen çocuklar arasındaki tek ve çift görev yürüme parametrelerini karşılaştırmayı amaçladı.
Yöntem: Tek ve çift görev koşulları altında 10 metre yürüme testi ile değerlendirilen yürüme parametreleri (yürüyüş hızı, kadans ve çift adım uzunluğu) ve çift görev maliyeti hesaplandı. Karşılaştırmalarda t-testi, Mann-Whitney U ve Pearson ki-kare testleri kullanıldı.
Bulgular: Karşılaştırmalı-tanımlayıcı araştırma, yaş ortalaması 12,45±2,71 olan 49 çocuk (14 kız, 35 erkek) ile yapılmıştır. Çalışma katılımcıları kanser tanılı (7 kız, 13 erkek) ve normal gelişim gösteren (7 kız, 22 erkek) çocuklar olmak üzere iki gruptan oluşmaktaydı. Kanser tanılı çocuklar grubu, tek görev koşulu altında daha düşük yürüme hızı (p<0,001) ve kadans (p<0,001) sergiledi. Bilişsel çift görev koşulu altında, kanser tanılı çocuklar grubunun daha düşük yürüme hızı (p<0,001) ve kadansı (p<0,001) vardı. Ayrıca yürüme hızı (p<0,001) ve kadans (p<0,001), motor çift görev koşulunda kanser tanılı çocuklar grubunda daha düşüktü. İki grubun çift adım uzunlukları ve çift görev maliyeti değerleri arasında fark yoktu (p>0,05).
Sonuç: Sonuç olarak, çalışma kanser tanılı çocukların tek ve çift görev yürüme parametrelerinde sapma olabileceğini göstermiştir. Kanser tanılı çocuklardaki tek ve çift görev yürüme parametrelerinin değerlendirilmesi, rehabilitasyon ihtiyaçlarının belirlenmesine katkıda bulunacaktır.
Anahtar kelimeler: Kanser; Çocuk; Yürüme analizi; Görev performansı; Rehabilitasyon.

Abstract

Purpose: *This study aimed to compare single- and dual-task gait parameters between children with cancer (CC) and typically developing children (TDC).*
Methods: *The gait parameters (gait speed, cadence, and stride length) assessed by the 10-meter walking test under single- and dual-task conditions and dual-task cost (DTC) was calculated. The t-test, Mann-Whitney U, and Pearson chi-square tests were used for comparisons.*
Results: *The comparative-descriptive study was conducted with 49 children (14 females and 35 males) with a mean age of 12.45±2.71. The study participants consisted of two groups: CC (7 girls, 13 boys) and TDC (7 girls, 22 boys). The CC group exhibited lower gait speed (p<0.001) and cadence (p<0.001) under the single-task condition. Under the cognitive dual-task condition, the CC group had lower gait speed (p<0.001) and cadence (p<0.001). Also, gait speed (p<0.001) and cadence (p<0.001) were significantly lower under the motor dual-task condition in the CC group. There was no difference between the two groups' stride lengths and dual-task cost values (p>0.05).*
Conclusion: *Consequently, the study demonstrated that CC might have a deviation in single- and dual-task gait parameters. Assessments of single- and dual-task gait parameters in CC will contribute to the identification the rehabilitation needs.*
Keywords: *Cancer; Child; Gait analysis; Task performance; Rehabilitation.*

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INTRODUCTION

Cancer, one of the chronic disorders, takes place among the most important health problems experienced during childhood in the world. Although the developments in the treatment methods such as chemotherapy and radiotherapy have recently increased the survival rate it is stated that these treatment methods can cause mental, cognitive and physical deficits in children with cancer.[1] Most studies on children with cancer (CC) reveal that the disease and its treatment cause long-term side effects on the musculoskeletal system, physical functions, gait, and cognitive skills.[1,2] The therapies used for CC can change the child's gait characteristics by adversely affecting the functioning and structure of the lower extremity or nervous system. Some studies assessing these changes have revealed that individuals with bone tumor lesions in lower extremities and nervous system tumors experience function loss and physical deficits.[3] In a study, it was determined that gait disorders were observed in children with bone and central nervous system tumors and all pediatric oncology individuals.[4] Active ankle dorsiflexion, gait parameters (stance, swing, and pre-swing phase), and walking efficiency were significantly impaired in a mixed childhood cancer survivor population compared with the control group in the study.[4] In addition, most studies have emphasized that children with chemotherapy-induced peripheral neuropathy exhibited electromyography, kinematic, kinetic, and spatiotemporal deviations throughout the gait cycle.[5,6]

The changes in cognitive functions occurring in CC are caused by the interference of complicated factors such as genetic predisposition, cancer type, age, and treatment method. The late effects on cognitive skills include attention and concentration deficits and dysfunction in working memory, processing speed, and executive functions.[3] Working memory generally refers to a system that storage a limited amount of information available for cognitive operations.[7] The developmental process of working memory in children is evaluated with a dual-task paradigm.[8] Dual-task is defined as performing two different tasks simultaneously.[9] Overlapping two tasks in working memory causes dual-task interference, leading to competition in cognitive resources with a reduction in working memory capacity, thus creating a less efficient performance when two tasks are concurrently performed.[8] Dual-task interference, known as dual-task cost (DTC), is the deficit occurring in the performance of one or both tasks as a result of performing two different tasks simultaneously and is calculated by the difference between dual-task performance and single-task performance.[10] For example, the gait speeds of individuals may decline while simultaneously performing a cognitive task.

Nowadays, dual-task exercises are included in rehabilitation programs for children with many motor and cognitive disorders.[11,12] Comparing the dual-task performance of CC with typically developing children (TDC) may be clinically helpful in guiding future treatments. Therefore, this study aimed to compare the gait parameters and DTCs under single-task and dual-task conditions between CC and TDC.

METHODS

Design

This study was a comparative-descriptive study performed by the principles published in the Helsinki Declaration of Human Rights. The Clinical Research Ethics Committee approved the study protocol of the Afyonkarahisar Health Science University (Number: 2021/144 Date: 05/02/2021). Before data collection, the children and guardians obtained written informed consent recommended by the World Health Organization Research Ethics Review Committee for clinical studies.

Participants

The sample of this study comprised CC receiving treatment in the pediatric hematology-oncology clinic of a university hospital or being followed up in the outpatient clinic in Afyonkarahisar. The TDC were healthy siblings of CC. The sample size was determined by G*Power V.3.1.7 (University of Kiel, Kiel, Germany) program. The inclusion criteria for the CC group were as follows: being between 9 and 18 aged of both genders,[13] with the ability to follow verbal instructions, having been diagnosed with an oncologic disease, receiving active treatment (chemotherapy, radiotherapy, or combined therapy), and having no physical limitation or secondary disease. The exclusion criteria were as follows: staying in an isolated room or having an infection risk, having undergone lower extremity or spinal surgery, having a comorbid disease (physical, neurological, mental, cardiovascular, etc.), having cognitive impairment, or using any assistive device while walking. In addition, the study recruited age- and gender-matched healthy controls (TDC group) with the CC group. The inclusion criteria for the TDC group were as follows: being aged 9–18 years of both genders and with the ability to follow verbal instructions, and not having any diseases (physical, neurological, mental, or cardiovascular).

Measures

The study data were obtained from the pediatric hematology-oncology clinic and a local school between March-July 2021. The primary outcome measures included spatiotemporal gait parameters (gait speed, cadence, and stride length parameters) assessed by the 10-meter walking test under single- and dual-task conditions and calculation of DTC values.

Data were collected using a protocol approved by the researchers. The researchers were composed of a pediatric hematologist-oncologist, a pediatric oncology nurse, and two physiotherapists (one of the physiotherapists had 7-years of experience in pediatric rehabilitation and the other physiotherapist had gait assessment experience of over 10-years). A researcher (pediatric oncology nurse) who knew the CC in the clinic collected the demographic data according to family and child expressions. The other two independent researchers (two physiotherapists) performed the gait assessment together. The same researchers (all independent of the TDC group) assessed the TDC group similarly. All the assessments were conducted at an exercise and a playing room in the hematology-oncology clinic. During the assessments, none of the children had any problems with understanding the assessment instructions.

The effect size was accepted as d=0.875 which was obtained from gait speed results in the reference study; it was calculated that an 80% power could be obtained in a 95% confidence interval when at least 18 participants were included in each group in the study.[5]

Child information form

The child information form was used in the collection of demographic data. This form consisted of questions about sociodemographic and descriptive characteristics (age, gender, Body Mass Index [BMI], diagnoses, treatment received, etc.) of the children.[14]

Gait assessment

Gait parameters were assessed with the BTS G-Walk® (BTS, Italy) device using the 10-meter walking test under single- and dual-task conditions. G-Walk is an approved and reliable wearable wireless sensor device clinically used for gait measurements in children.[15,16] This device includes an accelerometer and gyroscope and can define spatiotemporal gait parameters while walking.

For the gait assessment, the participant's demographic data (age, height, and gender) was entered into the device software, and then the walking test was selected on the interface. Then, the BTS G-walk device was attached to the participant's L4-L5 intervertebral disc level with a belt during the test. Finally, the participant walked on a 10-meter flat surface at their usual pace with regular footwear. When the gait assessment was completed, the device automatically calculated the gait data, and the software automatically processed the information and presented it to the researchers in graphs and tables. An assessment required an average of 2 minutes. The children were allowed to rest for a sufficient time between the assessments.

Gait assessment under single-task conditions: The gait was assessed on a flat and firm surface without adding any cognitive or motor tasks (Figure 1, A).

Gait assessment under dual-task conditions was performed in two ways: Gait assessment in combination with a cognitive task (cognitive dual-task) and gait assessment in combination with a motor task (motor dual-task).

Cognitive dual-task (CDT): In this assessment, a 10-meter walking test and an auditory 1-back test were simultaneously performed. For the auditory 1-back test, the lists, including the stimuli numbers (0-9) to be remembered, were recorded with a female voice. The numbers were randomly put in an order so that no repeats (8-8; 2-2) and series (1-2-3; 7-8-

9) were included and presented as the participants could easily hear during the task. The participants had to remember the priory presented numbers and loudly tell a previous number (1-back) from the new number when the new number was presented. As soon as the participants said the first number, they started walking for the gait assessment. The participants continued to perform the 1-back test until the end of the walking.[17] (Figure 1, B)

Motor dual-task (MDT): The participant received the 10-meter walking test while carrying a glass of water (4 cm diameter, 90 g curb weight; 3/4 part of it was filled with water). The participant was asked not to pour the water during the assessment (Figure 1, C).[18]

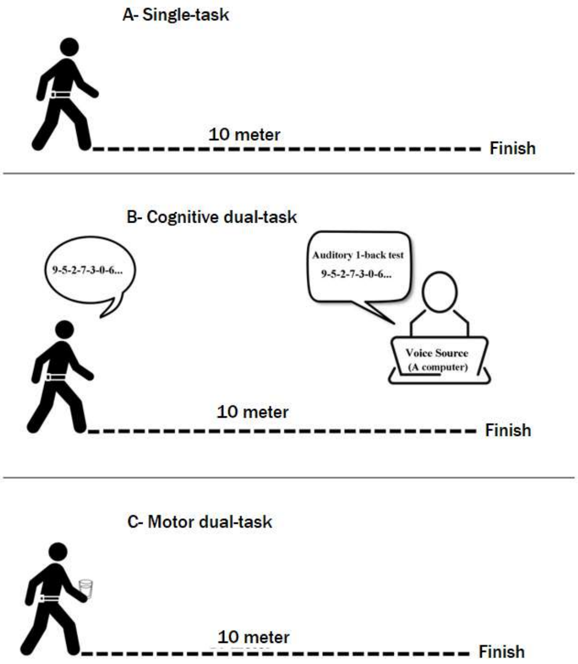

Figure 1. Gait assessments.

A trial test was performed before the walking tests, and rest was allowed after each. Finally, the DTC was calculated after the gait was assessed under single- and dual-task conditions (DTC= (single-task score – dual-task score)). A positive DTC value exhibits how much the performance of the individual gets worse during DT performance compared with the single-task conditions and how the performance cost increases.[8] Individuals generally use activities combining more than one task (multiple tasks) daily, but this combination increases the performance cost compared with single-tasks, which reveals the clinical importance of DT cost.[19]

Statistical analysis

IBM SPSS Statistics 21.0 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0, Armonk, NY, USA: IBM Corp.) software program was used in data analysis. Any subjects with missing values related to gait parameters and descriptive characteristics were excluded from the analysis. The conformity of the data to normal distribution was assessed with the Shapiro-Wilk test. Normally distributed variables (single-task gait speed, single-task cadence, CDT gait speed, CDT cadence, CDT stride length, MDT cadence, MDT stride length, CDT DTC gait speed, CDT DTC cadence, MDT DTC gait speed) were revealed as mean ± SD, skewed distributions (age, BMI, single-task stride length, MDT gait speed, CDT DTC stride length, MDT DTC cadence, MDT DTC stride length) were indicated as median with interquartile range, and frequencies were used to present categorical variables (gender, diagnoses, type of treatment, treatment phases). For normally distributed data, the t-test was used, while the nonparametric Mann-Whitney U test was employed for skewed distributions. The chi-squared test was used for analyzing categorical variables.[20]

RESULTS

Fifty-seven individuals (24 in the CC group and 33 in the TDC group) were assessed for eligibility in the study. Seven participants who did not meet the inclusion criteria (3 children who were misdiagnosed or had comorbidities in the CC group, 4 who did not meet the age criteria in the TDC group) and had missing data (1 in the CC group) were excluded from the study. Eventually, the study was completed with a total of 49 individuals (14 female and 35 male participants) with a mean age of 12.45±2.71 and a mean BMI of 18.22±3.76 (Figure 2).

Descriptive data of the participants were presented in Table 1. Two groups were similar

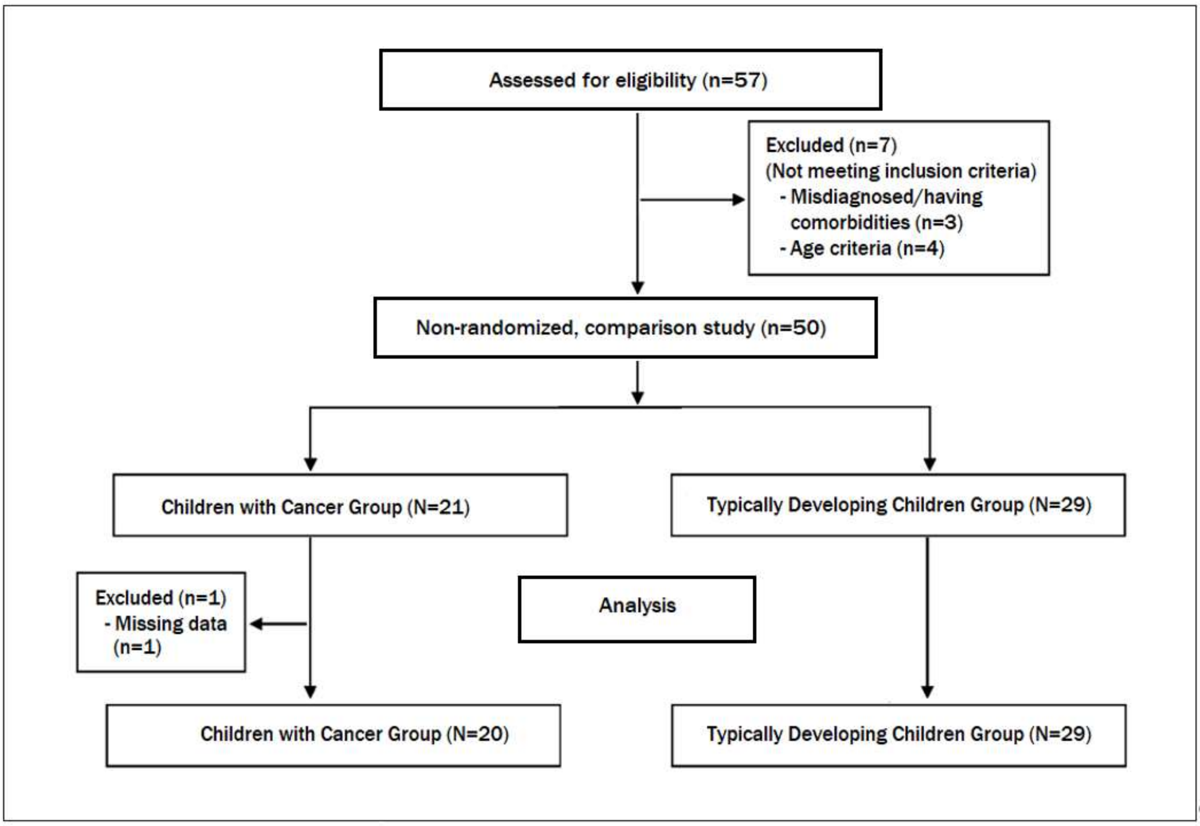

Figure 2. Flowchart of the study.

in terms of age (p=0.14), BMI (p=0.24), and gender (p=0.41).

Under single-task conditions, the CC group showed a significantly lower gait speed (t=-4.62; p<0.01) and cadence (t=-8.07; p<0.01) when compared to the TDC group. There were no differences between the two groups regarding stride length (U=239.50; p=0.30). The CC group exhibited a lower gait speed (t=-5.33; p<0.01) and cadence (t=-8.49; p<0.01) when compared to the TDC group under the CDT condition. Also, the two groups were similar in stride length (t=-1.25; p=0.27). The between-groups comparison indicated that the CC group had a significantly decreased gait speed (U=88.50; p<0.01) and cadence (t=-7.52; p<0.01) than the TDC group under MDT conditions. There were no differences between the two groups regarding stride length (t=-1.13; p=0.27) (Table 2).

There was no difference between CC group and TDC group in terms of DTC gait speed (t=0.19; p=0.85), cadence (t=1.21; p=0.23) and stride length (U=288.00; p=0.97) under CDT condition. Also, no significant differences between the two groups in terms of DTC gait speed (t=-0.32; p=0.75), cadence (U=236.00; p=0.27), and stride length (U=236.00; p=0.58) under MDT condition (Table 3).

Also, single- and dual-task gait parameters were compared between the CC who received chemotherapy and combined treatment in the study. However, no difference was found between the two groups regarding any single- and dual-task gait parameters (p>0.05).

DISCUSSION

Every year, about 400.000 children and adolescents are diagnosed with childhood cancer. The nature of childhood cancer and aggressive treatments considerably affect the motor and cognitive skills of the CC.[21,22] This study demonstrated that CC exhibited slower

Table 1. Characteristics of the participants.

	CC Group (N=20) Median (IQR)	TDC Group (N=29) Median (IQR)	p
Age (year)	12.00 (6.00)	11.00 (6.00)	0.14 (a)
Body Mass Index (kg/m^2)	18.32 (7.29)	17.33 (3.21)	0.24 (a)
	n (%)	n (%)	
Gender (Female/Male)	7/13 (35/65)	7/22 (24/76)	0.41 (b)
Diagnosis			
Acute lymphoblastic leukemia (ALL)	12 (60)	-	-
Acute myeloid leukemia (AML)	2 (10)	-	-
Solid tumor (Ovarian, testicular, renal tumor)	6 (30)	-	-
Type of treatment			
Chemotherapy only	14 (70)	-	-
Radiotherapy only	-	-	-
Combined	6 (30)	-	-

CC: Children with Cancer. TDC: Typically Developing Children. (a): Mann-Whitney U Test. (b): Pearson's Chi Square Test.

Table 2. Intergroup comparisons of single- and dual-task gait parameters.

	CC Group (N=20)	TDC Group (N=29)	p
	X±SD	X±SD	
Single-task			
Gait speed (m/s)	0.97±0.18	1.24±0.22	<0.01 (c)
Cadence (steps/min)	104.72±10.67	128.56±9.82	<0.01 (c)
Stride length (m) (Median (IQR))	2.22 (0.43)	2.41 (0.69)	0.30 (a)
Cognitive Dual-task			
Gait speed (m/s)	0.74±0.18	1.02±0.18	<0.01 (c)
Cadence (steps/min)	91.56±12.53	118.60±8.14	<0.01 (c)
Stride length (m)	1.93±0.41	2.06±0.33	0.22 (c)
Motor Dual-task			
Gait speed (m/s) (Median (IQR))	0.82 (0.28)	1.17 (0.34)	<0.01 (a)
Cadence (steps/min)	100.91±11.78	122.55±8.40	<0.01 (c)
Stride length (m)	2.10±0.39	2.22±0.36	0.27 (c)

CC: Children with Cancer. TDC: Typically Developing Children. (a): Mann-Whitney U Test. (c): Independent t Test.

Table 3. Intergroup comparisons of dual-task costs.

	CC Group (N=20)	TDC Group (N=29)	p
	X±SD	X±SD	
Cognitive Dual-task			
Dual-task Cost-Gait speed	0.23±0.08	0.23±0.13	0.85 (c)
Dual-task Cost-Cadence	13.16±10.22	9.97±8.24	0.23 (c)
Dual-task Cost-Stride length (Median (IQR))	0.22 (0.34)	0.16 (0.31)	0.97 (a)
Motor Dual-task			
Dual-task Cost-Gait speed	0.10±0.06	0.11±0.11	0.75 (c)
Dual-task Cost-Cadence (Median (IQR))	3.25 (5.15)	3.97 (9.89)	0.27 (a)
Dual-task Cost-Stride length (Median (IQR))	0.15 (0.19)	0.34 (0.36)	0.58 (a)

CC: Children with Cancer. TDC: Typically Developing Children. a: Mann-Whitney U Test. c: Independent t Test.

gait speed and less cadence when walking than TDC single- and dual-task conditions (cognitive and motor). Interestingly, shifting from the single-task conditions to the dual-task conditions did not reveal more dual-task costs for CC compared with TDC. Nevertheless, this study indicated that CC had an inefficient gait pattern (in terms of gait parameters) under single- and dual-task conditions compared to TDC.

Gait analysis determines gait deviations and gait anomalies in clinics and research. There are many methods used in gait analysis.[23] One is the evaluation of gait kinematics by wearable sensors and comparison with normative values. In this study, when the gait parameters of the children receiving cancer treatment under single- and dual-task conditions were compared with the normative values and the control group, it was observed that the gait parameters deviated from the normal.[13] We think motor and cognitive impairments that develop in children with cancer may cause these gait deviations. Studies in literature have generally assessed the single-task gait parameters of CC developing peripheral neuropathy due to chemotherapy.

This study demonstrated that single- and dual-task gait speed decreased in CC. In one study comparing single-task gait parameters in children with cancer who had vincristine neuropathy with a healthy control group, it was found that CC who had vincristine neuropathy walked more slowly.[5] In a previous study, the single-task gait of children diagnosed with acute lymphoblastic leukemia (ALL) post-chemotherapy neuropathy and healthy controls was evaluated with 3D motion analysis systems and electromyography. As a result, it was found that the CC group with neuropathy exhibited a slower gait pattern.[6] In another study, single-task gait parameters in children receiving intensive cancer treatment and healthy controls were compared using the 10-meter walking test. The study data confirmed that children with cancer receiving intensive treatment were slower on the 10-meter walking test that was performed by fast walking speed (single-task) than healthy controls. However, there was no difference between the two groups in terms of the 10-meter walk test that was performed via preferred walking speed.[24] The results obtained in this study are similar to the results of other studies in the literature. However, to the authors' knowledge, there is no other study in the literature comparing dual-task gait speed in CC with TDC. Most studies in the literature have attributed slower walking in CC to neuropathy, decreased ankle joint motion, or motor impairments such as decreased ankle muscle strength following chemotherapy.[5,24] No studies have focused on the effect of cognition on gait speed.

Studies evaluating cadence in CC are limited in the literature. Only Gilchrist and Tanner[5] compared CC with neuropathy and healthy controls regarding cadence in single-task gait performance. They emphasized that there was no difference. In this study, cadence in single- and dual-task gait was reduced in CC. Alaniz et al.[25] compared the single-task gait of children with ALL suspected peripheral mononeuropathy with normative data and found parallel findings with our study and stated that cadence decreased in children with cancer. The differences between the results of the studies may be related to the different assessment methods used in the studies. More studies on cadence are needed.

In this study, the stride length of CC was similar to that of typically developing children in both single- and dual-task gait assessments. In Gilchrist and Tanner's study,[5] the step lengths of CC in single-task gait assessments were shorter than those of TDC. Wright et al.[6] also noted findings similar to Gilchrist and Tanner's study. Beulertz et al.[4] showed that in a mixed population of childhood cancer survivors, step lengths of cancer survivors were similar to those of TDC. No other study was found in the literature that evaluates stride length in single- and dual-task conditions in CC, as in our study. According to the authors, the similarity of the findings of this study with the study of Beulertz et al.[4] might be explained by the mixed populations of childhood cancer in both studies. Additionally, CC in the other two studies had a diagnosis of neuropathy, unlike our study.[5,6] Therefore, it is thought that a difference in step lengths may have been found in the other two studies.

The primary task evaluated in terms of dual-task in this study was walking. When a secondary task (motor or cognitive) was added to walking, a decrease in walking performance was observed in both CC and TDC. Gait performance loss in both groups can be attributed to the interferences between primary and secondary tasks in the dual-task paradigm and is defined as dual-task cost.[26] According to the current findings, the increase in dual-task cost did not differ between CC and TDC, which is surprising because several studies on children with cancer have revealed that they are at a disadvantage compared to their healthy peers in cognitive and motor skills.[4,6] In the current study, single- and dual-task gait parameters were below the normative values compared to controls. Perhaps learning may have affected these results. In the study, dual-tasks were performed after the single-task. Learning the primary (walking) task and focusing the children's attention on the secondary task may have caused the value of the dual-task cost in both groups to be too low to distinguish between the two groups.

In this study, gait parameters were not affected by the type of treatment received by CC. To the knowledge of the authors, there is no study comparing gait parameters according to the type of treatment. However, regardless of the type of cancer, the risk of cognitive impairments due to cancer increases depending on age (starting treatment at a young age), cranial radiation therapy, parenteral or intrathecal methotrexate use, gender (female), and presence of comorbidities.[27] Researches indicate that therapeutic agents can affect gait and cause falls through neurotoxicity, with a combination of impairments in sensory, motor and cognitive domains.[28] Perhaps more disorders in gait parameters may be expected in the group receiving combined treatment. However, the treatment dose has a vital impact on the development of disorders caused by the type of treatment.[29] The similarity of gait parameters between the two groups may be explained by the effect of the different treatment doses applied.

Limitations

This study has some limitations. Firstly, the participants in this study were children with cancer from only a university hospital limiting the generalizability of the results. Secondly, performing single- or dual-task gait assessments in a nonrandomized order may have resulted in children learning the primary task, affecting study results. Finally, another limitation was that children's cognitive functions were not assessed in the study.

Conclusion

This is the first study assessing both single- and dual-task gait parameters in CC and reveals that the single- and dual-task gait parameters deviate in CC comparison with TDC. Therefore, single- and dual-task gait assessments in CC will contribute to the identification of children's rehabilitation needs and their inclusion in proper intervention programs (single- and dual-task training, etc.). Moreover, the risk of falling may decrease, and active participation in daily life may be encouraged for these children by single- and dual-task training. However, further studies evaluating single- and dual-task gait and calculating dual-task costs in children with CC are needed in the future.

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