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A Comparative study on the assessment of dual task performance in rheumatic diseases☆

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ABSTRACT

Background: In task-oriented studies showed that the chronic pain is effective on dual tasks. Chronic pain is the main health problem that prevents mobility restriction and participation in most rheumatic diseases.
Research question: Do rheumatic diseases have an effect on dual task gait performance?
Methods: This comparative-descriptive study included 75 individuals who aged 18–65 years and divided in two groups as Rheumatic Disease Group (RG; 23 women, 14 men) and Control Group (CG; 20 women, 18 men). The individuals have a chronic pain (> 3.4 cm according to Visual Analogue Scale, VAS) and Standardized Mini Mental State Examination score above 24 were included in this study as the RG. The individuals who were did not have any known disease were included in the CG. The health status of RG was evaluated with the Arthritis Impact Measurement Scale 2 (AIMS-2). The 10-meter Walk Test was applied under single and dual task conditions (dual task cognitive, $DT_{cognitive}$; dual task motor, DT_{motor}) for assessing gait performance.
Results and significance: The mean age of the individuals in the study was 40.6 ± 11.34 years (RG=43.08 ± 11.30; CG=38.18 ± 11.00). There was a significant difference in favor of CG between the groups both in terms of gait speed in $DT_{cognitive}$ and its cost ($p < 0.05$). VAS scores correlate with single and $DT_{cognitive}$ and DT_{motor} gait parameters ($p < 0.05$). Many subdivisions of AIMS-2 were associated with single, $DT_{cognitive}$ and DT_{motor} gait parameters ($p < 0.05$). This study concluded that rheumatic diseases may reduce gait performance in concurrent motor-cognitive dual task conditions due to chronic pain. Single and dual task gait parameters may be related with psychosocial factors. Therefore, applications including pain control and biopsychosocial approach may be beneficial in the management gait disturbances and falls due to a rheumatic disease.

1. Introduction

Rheumatic diseases influences the musculoskeletal system, including joints, muscles, connective tissues, soft tissues and characterized by pain and a consequent reduction in the function and range of motion; in some diseases there are indications of inflammation: swelling, redness, warmth in the affected areas. Since other organs and systems in the body are also affected. Almost 2 billion people of all ages are affected at some

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point during their life time because of rheumatic diseases that contain more than 100 different diseases which span from various types of arthritis to osteoporosis and on to systemic connective tissue diseases [1]. Chronic pain is a common health problem associated with most rheumatic diseases. 40–60% of individuals rheumatic diseases with do not have sufficient relief from their pain [2].

It is suggested in the literature that chronic pain has effects on certain cognitive areas. Chronic pain has been associated with impairments in cognitive function, including information processing speed, inhibitory control, judgement, attention, working memory, and short and long-term memory [3]. Also, task-oriented studies have shown that chronic pain does not have an effect on simple tasks, but rather on dual tasks that require the use of complex cognitive function (executive function) [4,5].

A task is a behavior, skill or ability that needs to be achieved [6]. The single task contains only one stimuli or task. Dual task is the simultaneous performance of two different tasks that can be measured independently and have different goals [7]. Dual tasks associated with falling risk [8] and mobility independence [9] constitute a large part of daily living activities [10,11]. As a result, individuals who experience impairment in walking in dual task conditions may be highly limited in their daily lives and may be at risk of falling and serious injury [12]. Recently, single and dual task performances have been evaluated in many disease groups in the field of physiotherapy and rehabilitation [13].

In the literature, there are several studies examining the dual task performance effect in individuals diagnosed with primary fibromyalgia [10] and osteoarthritis [13,14]. However, studies investigating the effects of rheumatic diseases such as rheumatoid arthritis, ankylosing spondylitis, systemic lupus erythematosus on dual task gait parameters have not been found in the literature. Chronic pain is the main health problem that prevents mobility restriction and participation in most rheumatic diseases [15–17]. Also, rheumatic diseases affect the physical, emotional and social functions of the individuals from the early stages of the disease due to the chronic process and the inadequacy it creates [18]. A previous study suggests that poor walking ability is associated with high diseases activity in Rheumatoid Arthritis [19]. Therefore, the primer aim of recent study was to evaluate the effect of chronic inflammatory rheumatic diseases on dual-task gait performance, secondly, state the possible correlation between dual task gait parameters and pain and health status.

2. Methods

2.1. Patients

To this comparative-descriptive study, individuals who consulted to the Physical Medicine and Rehabilitation outpatient clinic of the university hospital for routine treatment, diagnosed with rheumatic disease, 18–65 years old, have chronic pain that lasts longer than 3 months, have pain intensity over 3.4 cm according to the Visual Analogue Scale and have a Standardized Mini Mental State Examination score above 24 were included in this study as Rheumatic Disease Group (RG). Individuals with age-and gender-matched did not have any known disease (physical, neurological, cognitive) were included in the control group (CG). The exclusion criteria of the study were having any problem (physical, cognitive or psychological) that would hinder the evaluation and secondary diseases, being pregnant and undergoing lower extremity or spine surgery. The ethics committee approval of the study was obtained by the decision dated 06.11.2020 and numbered 2020/515. The study was carried out in line with the ethical principles of the Declaration of Helsinki. Before the evaluation, each individual was verbally informed about the aims of the research and the applications to be practiced, and their written consent was obtained.

2.2. Outcome measures

In the study, demographic information (age, gender, body mass index, education year) of all individuals were recorded. Standardized Mini Mental State Examination was applied to evaluate global cognitive functions. Also, the Visual Analogue Scale (VAS) was applied to evaluate the pain severity, and the effects of the disease on health status were evaluated with the Arthritis Impact Measurement Scale 2 (AIMS-2) in RG. Gait assessments under single and dual task conditions were applied to both groups with a 10-meter walk test. The evaluations were performed by 3 specialist in this field physiotherapists with at least 10 years of clinical experience. Before the study, the evaluators discussed the evaluation guidelines and the contradictions that may be encountered during the evaluations, so that all evaluations can be carried out in a standard way.

2.2.1. Standardized mini mental state examination (SMMSE)

SMMSE, which allows evaluating general cognitive performance. Total score is 30 points and the cut-off value for mild and moderate dementia is 23/24 points. A higher score is associated with better cognitive function [20].

2.2.2. Visual analogue scale (VAS)

The individual was asked to mark the intensity of their pain on the 10-cm line. The cut-off values for chronic diseases are VAS score < 3.4 cm referred to mild, those with 3.5–7.4 cm referred to moderate and those with ≥ 7.5 cm referred to severe pain [21,22].

2.2.3. 10-Meter walk test

It is applied by walking the individual at their normal gait speed (like walking in a shopping mall) on a flat surface marked 10 m without a walking aid and without any assistance. To avoid the impact of the acceleration and deceleration phases of gait, this test is conducted within the 10-meter portion of the 14-meter distance (2 m at the start and end are not included in the assessment). With the "Start" command, the time is started and at the finish line, the time is stopped and elapsed within 10 m is recorded [23]. In the study, it was applied with the portable and wearable sensors of LEGSys device (Newton, MA/USA). The sensors were placed just above individuals' ankles. With the use of the device, the spatiotemporal characteristics of the gait (gait speed, cadence and stride length) were objectively evaluated.

The 10-meter Walk Test was evaluated under single and dual task conditions.

2.2.3.1. Single task gait assessment (ST). Assessment was carried out with the 10-Meter Walk Test and without adding any cognitive or motor secondary task.

2.2.3.2. Dual task gait assessment. Assessment of gait performance under dual task conditions was applied in two different ways with the 10-meter walk test.

I. Gait performance was assessed with the cognitive task of counting backward by threes from a randomly selected number from 80 to 99 (dual task cognitive, $DT_{cognitive}$).

II. By combining with the secondary motor task of carrying a glass of water in hand (dual task motor, DT_{motor}).

The spatiotemporal (gait speed, cadence, stride length) characteristics of the gait were recorded during the assessments.

After gait was assessed under dual and single task conditions, dual task costs ($DTC_{cognitive}$ and DTC_{motor}) for $DT_{cognitive}$ and DT_{motor} were calculated with the following formula [12]:

$DT_{kognitif}$ skor−ST skor.

$DTC = ((DT_{cognitive\ score} - ST_{score})/DT_{cognitive}) \times 100.$

$DT_{kognitif}$ skor.

The condition of dual task cost is negative indicates that dual task performance worsens compared to single task performance. In other words, it is more difficult for an individual to achieve two tasks simultaneously than to achieve one task alone [12]. The clinical significance of the dual task cost is this; people often use activities that combine multiple tasks (multitasking) in their daily life activities, but this combination increases the cost of performance when compared to single tasks [24,25].

2.2.4. Arthritis impact measurement scale 2 (AIMS-2)

AIMS-2 is a multidimensional, disease-specific, self-assessment questionnaire designed to measure health status outcomes in patients with arthritis [26].

3. Statistics

SPSS 21.0 package program was used in the analysis of the study data. The compliance of the data to normal distribution was evaluated with the Kolmogorov Smirnov test. In the study, it was determined that the data met the parametric test hypothesis conditions. Comparisons of demographic data between groups were evaluated with t test and Pearson's Chi Square test, gait parameters and dual task cost comparisons by MANCOVA. Education time was considered as a covariant variable. Pearson correlation analysis was applied to evaluate the relationship of AIMS-2 scores and VAS with gait parameters. Analysis results are presented as mean ± standard deviation. The significance level was taken as $p < 0.05$.

3.1. Power analysis

The power analysis of the study was performed with the G-Power 3.1.9.7 program, with a priory analysis, to determine the fixed effects, special, main effects and interactions. When the main effect size is accepted as f= 0.40 [27], it was calculated that at least 52 individuals in total should be included in the study in order to achieve a significance level of 5% and a power of 80%. Assuming a 20% drop out from the study, the total number of individuals to be included in the study was planned to be at least 62.

4. Results

In the study, 78 individuals who agreed to participate in the study were reached and 3 individuals (RG) were excluded from the study because they did not meet the inclusion criteria (2 of the individuals did not meet the age criteria, one of them had a VAS score of <3.4). The study was completed with a total of 75 individuals, 43 (57.33%) women and 32 (42.66%) men. The flowchart is shown in Fig. 1. The mean age of the individuals was 40.6 ± 11.34 years. Their mean BMI was 27.83 ± 5.55 kg / m2, education time was 12.81 ± 6.17 years, and SMMSE was 26.56 ± 1.32 points.

The demographic information of the groups is given in Table 1.

In the study, 17 (45.9%) individuals with a diagnosis of rheumatoid arthritis, 13 (35.1%) with ankylosing spondylitis and 7 (%19) other (scleroderma, Behçet's disease, familial Mediterranean fever, fibromyalgia and psoriatic arthritis) were included. The mean VAS value of the individuals in the RG was 5.69 ± 2.31 and the disease duration was 10.42 ± 9.51 years. The mean scores of the subdivisions of AIMS-2 were physical 3.95 ± 2.00, social interaction 4.40 ± 1.55, symptom 6.53 ± 2.51, role 1.40 ± 2.49, affect 4.75 ± 2.70, satisfaction 4.88 ± 2.44, perception of health 6.05 ± 2.59, and arthritis effect 5.27 ± 2.34.

The comparison of gait parameters between groups is given in

Table 1
Demographic data of the participants.

	Groups		p value
	RG (n = 37)	CG (n = 38)	
Age (year)^{t}	43.08 ± 11.30	38.18 ± 11.00	0.061
BMI (kg/m^2)^{t}	28.89 ± 6.25	26.79 ± 4.63	0.103
Education duration (year)^{t}	7.70 ± 3.69	17.79 ± 3.38	0.001*
SMMSE^{t}	26.44 ± 1.56	26.69 ± 1.57	0.600
Female^{k}	23 (62.16)	20 (52.63)	0.157

* $p < 0.05$; ^{t} = variables are given as median±SD, t test was used.; ^{k} = variables are given as n (%), Pearson's chi square test was used; BMI=Body Mass Index; SMMSE=Standardized Mini Mental State Examination

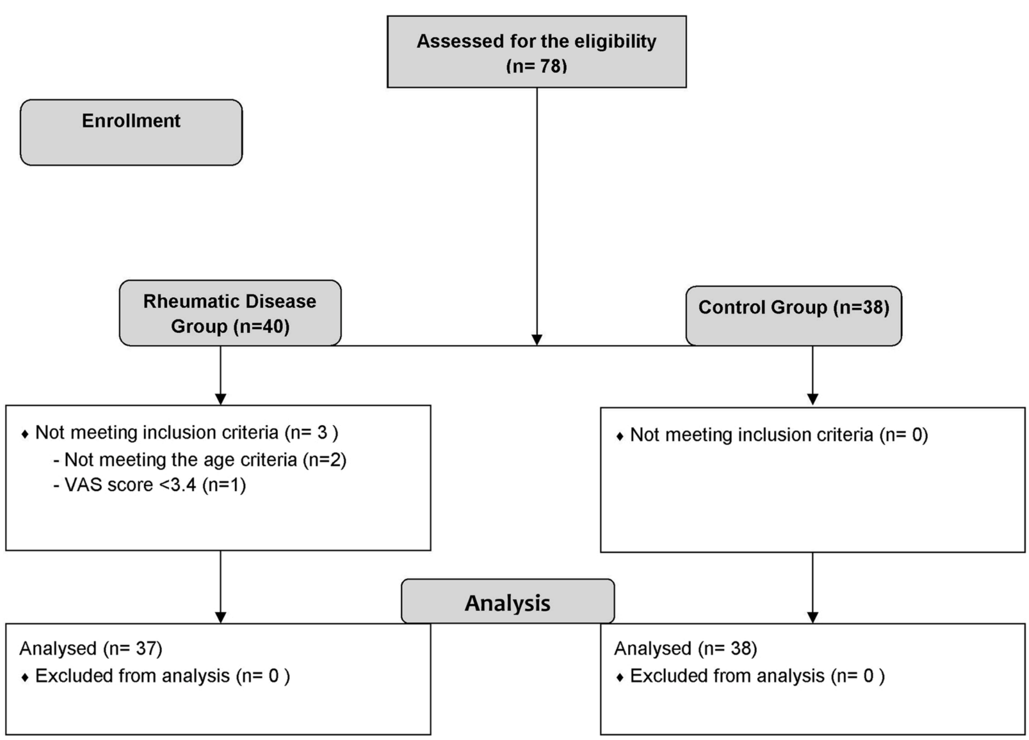

Fig. 1. Flow diagram of the study design.

Table 2
Comparison of single and dual task gait parameters between groups.

Condition	Gait parameters	Groups		F value	p	η_p^2
		RG (n = 37)	CG (n = 38)			
ST	Gait speed (m/s)	1.15 ± 0.05	1.18 ± 0.05	0.18	0.68	0.01
	Cadence (steps /min)	104.56 ± 2.79	107.16 ± 2.51	0.32	0,57	0.02
	Stride length (m/s)	1.31 ± 0.04	1.32 ± 0.03	0.04	0.85	0.01
$DT_{cognitive}$	Gait speed (m/s)	0.78 ± 0.06	0.99 ± 0.06	4.25	0.04*	0.06
	Cadence (steps /min)	77.91 ± 4.17	91.59 ± 3.76	4.00	0.05	0.06
	Stride length (m/s)	1.25 ± 0.11	1.32 ± 0.10	0.16	0.69	0.01
DT_{motor}	Gait speed (m/s)	1.11 ± 0.05	1.18 ± 0.04	0.81	0.37	0.01
	Cadence (steps /min)	102.39 ± 2.89	108.12 ± 2.60	1.47	0.23	0.02
	Stride length (m/s)	1.32 ± 0.12	1.34 ± 0.11	0.01	0.92	0.01

* $p < 0.05$; DTcognitive=dual task cognitive; DTmotor=dual task motor; η_p^2 =Partial Eta Squared

Table 2.

When the education time was adjusted, it was concluded that there was a significant difference in favor of CG between the groups only in terms of $DT_{cognitive}$ gait speed ($p < 0.05$).

The relationship of VAS and AIMS-2 scores of the RG with gait parameters are shown in Table 3.

Pain is moderately associated with ST gait speed ($r = -0.41$) and stride length ($r = -0.45$), $DT_{cognitive}$ gait speed ($r = -0.43$) and DT_{motor} gait speed ($r = -0.48$) ($p < 0.05$). There was a weak correlation between pain and DT_{motor} cadance ($r = -0.25$) ($p < 0.05$). The relationship between the physical subdivision of AIMS-2 and ST gait speed ($r = -0.36$) and stride length ($r = -0.36$), and DT_{motor} gait speed ($r = -0.40$) was defined as a moderate level ($p < 0.05$). Symptom subdivision had a moderately significant relationship with only DT_{motor} gait speed ($r = -0.34$) ($p < 0.05$). Affect subdivision had moderate correlation with all parameters of gait except stride lengths ($p < 0.05$). The relationship between satisfaction subdivision with ST gait speed, ST stride length, $DT_{cognitive}$ gait speed and DT_{motor} gait speed was moderate and significant ($p < 0.05$). A moderate and significant relationship was found between perception of health and DT_{motor} gait speed and cadence ($p < 0.05$). There was no relationship between other variables (social interaction, role, arthritis effect) and gait parameters ($p > 0.05$).

Dual task cost comparisons of RG and CG are given in Table 4.

As a result of the intergroup comparisons made by adjusting the education time, the $DTC_{cognitive}$ gait speed of the RG increased more than the CG ($p < 0.05$). There was no difference between the two groups in terms of other parameters ($p > 0.05$).

5. Discussion

In this study, the effects of dual-task paradigms combining the walking task with a motor or cognitive task on gait performance were compared in individuals with rheumatic disease and healthy controls. Individuals with rheumatic disease were found to have slower gait speed and increased dual task cost when an additional cognitive task was added to walking compared to controls.

In the literature, the gait performances of the individuals with rheumatic diseases such as rheumatoid arthritis, osteoarthritis, and fibromyalgia were searched by evaluating basic gait parameters [10, 28–31]. It was stated that high disease activity in individuals with RA is an indicator of poor gait abilities and although they have good functional abilities in terms of health status, but disorders in gait abilities, and performance losses could be seen [32]. It has been reported that in these individuals, kinematic and kinetic gait parameters, especially gait speed, decreased [28,29]. In addition, some studies evaluating gait performance under dual-task conditions have stated that many individuals with rheumatic disease have pain, limited range of motion and reduced joint moments, emphasizing those normal gait parameters may be affected by dual-task conditions [13,28]. Similarly, in the recent study suggested that dual task gait parameters were altered with rheumatic diseases.

A review reported that individuals with knee osteoarthritis had a significant dual-task interaction between cognitive load and motor tasks, represented by a change in dual task costs [31]. It was found that when switching from a single task to dual tasks, gait duration increases in individuals with knee osteoarthritis [30] and dynamic postural control is weakened [14]. The women with primary fibromyalgia were reported to underperform physical fitness tests under single and dual task

Table 3
The relationship of AIMS-2 scores and VAS with gait parameters.

			Condition								
			ST			*$DT_{cognitive}$*			*DT_{motor}*		
			Gait Parameters of the RG (n = 37)								
			Gait speed (m/s)	Cadance (step/min)	Stride length (m/s)	Gait speed (m/s)	Cadance (step/min)	Stride length (m/s)	Gait speed (m/s)	Cadance (step/min)	Stride length (m/s)
AIMS-2	Physical influence	r	-0.36 *	-0.07	-0.36 *	-0.23	0.07	-0.17	-0.40 *	-0.09	-0.07
	Social interaction	r	-0.14	-0.23	-0.12	-0.12	-0.10	-0.26	-0.23	-0.23	-0.23
	Symptom	r	-0.24	-0.20	-0.09	-0.27	-0.22	-0.01	-0.34 *	-0.27	0.05
	Role	r	-0.17	-0.22	-0.06	-0.20	-0.29	-0.08	-0.16	-0.26	-0.10
	Affect	r	-0.40 *	-0.40 *	-0.19	-0.34 *	-0.35 *	-0.06	-0.42 *	-0.39 *	-0.07
	Satisfaction	r	-0.49 *	-0.25	-0.42 *	-0.51 *	-0.30	0.04	-0.60 *	-0.31	0.12
	Perception of health	r	-0.39	-0.24	-0.31	-0.20	-0.23	-0.06	-0.48 *	-0.33 *	-0.05
	Arthritis effect	r	-0.05	-0.02	-0.04	-0.01	-0.08	0.32	-0.08	-0.07	0.32
VAS		r	-0.41 *	-0.18	-0.45 *	-0.43 *	-0.16	-0.14	-0.48 *	-0.25 *	-0.03

*$p < 0.05$; r: Pearson's correlation coefficient; ST=single task; DTcognitive=dual task cognitive; DTmotor=dual task motor)

Table 4
Comparison of dual task costs between groups.

Condition	Gait parameters	Groups		F value	p	η_p^2
		RG (n = 37)	CG (n = 38)			
$DTC_{cognitive}$	Gait speed (m/s)	-76.55 ± 13.67	-22.04 ± 12.31	5.92	0.02*	0.09
	Cadence (steps /min)	-41.20 ± 7.99	-19.20 ± 6.30	3.69	0.06	0.06
	Stride length (m/s)	-7.49 ± 3.76	-2.28 ± 3.38	0.72	0.40	0.01
DTC_{motor}	Gait speed (m/s)	-3.31 ± 2.16	-0.61 ± 1.94	0.59	0.45	0.01
	Cadence (steps /min)	-2.45 ± 1.26	-0.79 ± 1.14	2.43	0.12	0.04
	Stride length (m/s)	-0.16 ± 2.71	-0.43 ± 2.44	0.01	0.95	0.01

* $p < 0.05$; η_p^2 = Partial Eta Squared; DTcognitive=dual task cognitive; DTmotor=dual task motor

conditions compared to controls [10]. The results in the recent study, similar to previous studies, showed that there was a decrease in the gait speed of individuals with rheumatic disease and dual task costs increased with walking, especially during an additional cognitive task. This may be due to the fact that chronic pain in rheumatic diseases may have negatively effect on cognitive processing that plays an important role in gait and individuals refer higher-level cognitive functions such as executive functions while gait [33]. The recent study showed that pain moderately correlate with gait parameters in single and dual task conditions. There are studies supporting results of the recent study in the literature indicating that chronic pain and high disease activity cause executive dysfunction [34,35]. Hamacher et al. confirmed the specific effects of cognitive dual task on gait variability in individuals with chronic low back pain. [13]. A systematic review examining the effect of dual-task on gait and balance performance in individuals with knee pain defined that there is a link between cognitive challenges and physical demands [31]. Alsultan et al. stated that individuals with neck pain exhibited slower gait during dual-task gait. However they explained these change with existing the fear of movement [36]. That may be because gait was evaluated in dual task conditions in which only two motor tasks were combined in the study. In the recent study, intergroup comparisons had no gait parameter changes were observed in the dual task created by combining two motor tasks, suggesting that chronic pain affects the dual task in cognitive condition by causing a dysfunction in executive function. A meta-analysis supported the recent study by revealing a small to moderate impairment in executive function performance in people with chronic pain [37].

AIMS-2 examines the extent to which an individual is affected by the disease due to rheumatism or other causes, according to physical, social interaction, symptom, role, affect, satisfaction, perception of health, and arthritis effect [26]. The recent study indicated that there was a correlation between health status and gait parameters in single and dual task conditions. Some studies obtained similar results. Yamada et al. explained the relationship between functional impairment and walking ability and gait speed in their study [29]. A cohort study of individuals with rheumatoid arthritis performed gait analysis to determine the factors associated with gait parameters in single task condition. According to the results of the study, the disease activity score was negatively associated with step length and gait speed [32]. Also, in recent study, gait speed was more correlated with affect and satisfaction subdivision of AIMS-2. The relationship of gait speed with the affect component of AIMS-2 in single and dual task conditions suggests that this parameter, which decreases in RG's individuals, may be affected by psychosocial factors. Similarly, it has been previously reported that slow gait speed in individuals with rheumatoid arthritis and osteoarthritis develops due to psychosocial factors such as higher depression and fatigue [38,39].

The recent study indicated that the gait speed and the dual task cost increased in dual task cognitive performance in individuals with rheumatic disease and moderate to severe chronic pain. In addition, it was found that a relationship between chronic pain and AIMS-2 scores and gait parameters in single and dual-task conditions. The strength of the recent study that no studies investigating the effect of rheumatic diseases such as rheumatoid arthritis, ankylosing spondylitis or systemic lupus erythematosus on dual-task gait performance were found in the literature.

6. Limitations

One limitation of the recent study is that there are differences in the education time between the groups. However, this difference was eliminated by adjusting education time by the statistical methods used. Another limitation is that rheumatic diseases had some sub-diagnosis within themselves and the results of the recent study could not be attributed to a single diagnostic group.

7. Conclusion

The recent study concluded that rheumatic diseases may reduce gait performance in dual-task conditions by causing chronic pain in individuals. Also, physical, cognitive and emotional factors may be related with single and dual task gait parameters in individuals with rheumatic diseases. Therefore, the recent study suggests that applications including biopsychosocial approach may be beneficial in the management of individuals with problems such as gait disturbances and falls due to a rheumatic disease. There is a need for more studies assessing dual task in specific sub-diagnosis groups of rheumatic diseases.

CRediT authorship contribution statement

Emel Tasvuran Horata: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Erdal Horata:** Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. **Yunus Emre Kundakci:** Investigation, Writing – original draft, Writing – review & editing. **Hilal Yesil:** Resources, Supervision, Writing – review & editing. **Suat Erel:** Resources, Writing – review & editing. **Umit Dundar:** Resources, Writing – review & editing.

Declarations Conflict of Interest

None.

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Author note

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Declaration of Competing Interest

We confirm that the authors declare that they have no financial support or relationships that may pose a conflict of interest.

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