Chapter

The Effect of a Proprioceptive Exercises Programme on Disease Activity and Gait Biomechanical Parameters of Post-Menopausal Women with Rheumatoid Arthritis

Pedro Aleixo, Tiago Atalaia, José Vaz Patto and João Abrantes

Abstract

This study aimed to assess the effects of a proprioceptive exercises programme on disease activity and on ankle kinematic and kinetic parameters of post-menopausal women with rheumatoid arthritis. Twenty-seven post-menopausal women with rheumatoid arthritis were allocated to exercise group (n = 15) or control group (n = 12). Exercise group intervention: proprioceptive exercises (12 weeks; 3 one-on-one workouts/week; 30 min/workout). Control group intervention: stretching exercises (12 weeks; 1 one-on-one workout every two weeks; 30 min/workout). Disease Activity Score (28 joints) was used to assess disease activity. A 3D motion analysis system (9 cameras, 200 Hz) and a force plate (1000 Hz) were used to collect kinematic and kinetic data during a barefoot walking at self-selected speed. For each subjects' foot, 7 trials of the stance phase were collected. One subject withdrawal was registered in exercise group. Post-intervention, exercise group' subjects yielded higher gait speed, shorter stance phase, shorter controlled dorsiflexion sub-phase, and higher ankle power peak ($p < 0.05$), however, they showed no differences in Disease Activity Score, ankle moment of force peak, and variability of biomechanical parameters; control group' subjects showed no differences in all parameters. Proprioceptive exercises seemed to be a safe option to gain gait biomechanical improvements in post-menopausal women with rheumatoid arthritis.

Keywords: rheumatoid arthritis, proprioceptive exercises, disease activity, gait, ankle kinematics, ankle kinetics

1. Introduction

Patients with rheumatoid arthritis (RA) present damaged joints and pain [1], low muscle strength values [2], and cachexia [3, 4], while post-menopausal women represent the greater percentage of these patients [5]. Otherwise, patients with RA [6] and post-menopausal women [7] also present an increased risk of fall. So, interventions aimed to reduce the risk and to prevent falls seem to be advisable for patients with RA, especially in the post-menopausal women group.

Falls have been associated with different identifiable risk factors [7, 8], which includes an unsteady gait [8] and an ineffective postural stability [9]. Gait and postural stability are dependent of motor control processes, assured by the central nervous system at different levels. According to literature, foot and ankle play a significant role to keep an effective postural stability in bipedal or unipedal activities [10], namely during gait [11, 12]. Furthermore, foot and ankle problems are associated with an increment of the risk of falls [13]. The control of the foot and ankle kinematics is especially important in the gait stance phase [14]. At gait stance phase, the ankle execute, in the sagittal plane, three different angular displacements, which were defined in prior studies as controlled plantar flexion, controlled dorsiflexion, and powered plantar flexion sub-phases [15–17]. These three angular displacements sub-phases are associated with the three objectives of foot control, mentioned in the literature [18, 19], that occurs in the gait stance phase: first, to control the impact on the ground; second, to control the foot as a stable limb; and third, to control the foot to propel the body. Consequently, ankle angular positions, ankle moment of force peak, and ankle power peak during stance phase have been reported as important biomechanical parameters for foot function measurement [20, 21]. Patients with RA have differences in ankle kinematics and kinetics during the gait stance phase, when compared with healthy controls, namely: at ankle angles [20–24]; lower ankle power peak [21, 22]; and lower ankle moment of force peak [21, 23, 24]. Moreover, previous studies [21, 24] correlated lower gait speeds – observed in these patients – with a reduced ankle moment of force peak and ankle power peak. According to the literature [23, 25], an impaired ankle power can reduce the capacity of adjustment and increment of gait speed, leading to a lower functional capacity. A subsequent study [14] specifically compared a group of post-menopausal women with RA with a group of age-matched healthy post-menopausal women. Data from this study showed that these patients yielded a lower ankle moment of force and a lower power performance during the powered plantar flexion sub-phase. The authors of this study concluded that it should be important to improve these kinetic values in post-menopausal women with RA, since they were vital concerning foot and ankle function, functional capacity, and fall prevention. According to the same study [14], post-menopausal women with RA also showed a higher stride-to-stride variability in the ankle moment of force peak. According to the literature, an increment of motor variability was also found in elders with history of falls [26–28], which could be a manifestation of an impaired motor control [29].

The nervous system, composed by the central nervous system and the peripheral nervous system, allows motor control during human movement. The central nervous system controls movement through three different levels (cerebral cortex, brain stem, and spinal cord), which are hierarchically organized, interdependent and connected between them: (1) the most complex voluntary movements are regulated by the cerebral cortex – upper level; (2) postural stability, as well as the automatic and stereotyped movements, are regulated by the brain stem – middle level; (3) movement is also regulated at the spinal cord – lower level [30, 31]. The peripheral nervous system enables the connection of the periphery with the middle and lower levels of the central nervous system [32]. Otherwise, the somatosensory information, composed by the mechanoreceptive, thermoreceptive, and nociceptive information arising from the periphery, also plays an important role in movement control [31]. Proprioception, a subcomponent of the somatosensory information, encompasses the afferent information arising from mechanoreceptors (located at the periphery) and contributes to joint and postural stability control [31]. This proprioceptive information is transmitted to the three levels of the central nervous system, providing an optimization of the motor control [33]. The reciprocal innervation, an essential mechanism of the spinal cord regulation of the movement, is dependent on the quality of proprioceptive information (e.g., information arising from neuromuscular spindle, Golgi tendon organ, and mechanoreceptors located in joints) [34]. Accordingly, the quality of the movement is reliant on proprioception, both at a global (postural) level and at a local (joint) level [33, 35]. Therefore, a specific exercise programme could be conducted specifically to challenge and improve proprioceptive mechanisms, enhancing motor control processes [36]. This kind of exercise, made with this goal, could achieve the denomination of proprioceptive exercise [37]. According to a systematic review [38], there is evidence that proprioceptive exercises programmes can lead to improvements in proprioception and somatosensory function, namely programmes lasting 6 or more weeks (longer programmes have a greater effect); however, authors also concluded that there was a great variability and lack of detail concerning the training parameters (e.g., weekly frequency and workout duration) defined in the selected studies, making impossible to know the optimal dose–response.

Several interventions to prevent falls in elderly (e.g., exercises programme, educational programme, medication optimisation, environmental modification, and multiple interventions) have been established and evaluated [39]. Exercise programmes can prevent falls in elderly, especially those that include "balance" exercises [40, 41]. "Balance", "coordination", and "postural" exercises were classified as proprioceptive exercises in previous studies [36, 42]. According to a previous study [43], the incidence of falls in elderly was reduced after a proprioceptive exercise program. Thus, exercise is a good contribution for preventing falls; however, proprioceptive exercises, with their specificity, contribute in a more decisive way, stimulating and enhancing motor control processes.

Patients with RA benefit from the safety of the aerobic training, strength training, and from combinations of both. This is evidenced in published systematic reviews and meta-analysis [44–47]. Nonetheless, it was concluded in a prior systematic review [42] that there is a lack of studies that approach the safety and effectiveness of proprioceptive exercises regarding the improvement of functional capacity of these patients. Although these authors had not found any randomized or controlled clinical trial, a more recent systematic review [48] concluded that there is some evidence that, the so called, proprioceptive exercises are safe to apply in patients with RA and helpful in the increment of their functional capacity. In parallel, proprioceptive exercises programmes have revealed effective in elderly regarding improvements of their gait biomechanical parameters [49–51]. Exercise programmes are important to prevent falls [40, 41, 43], however, proprioceptive exercises programmes differs from others by its capacity to stimulate and enhance proprioception and somatosensory function [38]. However, it is noted that to the best of our knowledge, the effects of a proprioceptive exercises programme on gait biomechanical parameters were not studied in patients with RA. Furthermore, researches that evaluate the safety of this kind of exercises, in patients with RA, are also required.

The previous rational supported the twofold aim of the present study. First, it aimed to evaluate the effects of a proprioceptive exercises programme on disease activity of post-menopausal women with RA. Second, it also aimed to evaluate the effects on ankle kinematics and kinetics during the gait stance phase and on its variability.

2. Methods

To achieve the defined aims, a prospective, single-blind, controlled but non-randomized trial study was conducted. The study was concepted in respect of the

Declaration of Helsinki [52] and approved by the Ethical Committee for Health of the Portuguese Institute of Rheumatology, Lisbon, Portugal.

2.1 Participants

The selected post-menopausal women with RA (n = 27) were recruited from the Portuguese Institute of Rheumatology, Lisbon, Portugal, and participated voluntarily in this study. Inclusion criteria were defined as follow, to allow a coherent sample: (1) diagnosis of RA was made according to the 2010 Rheumatoid Arthritis Classification Criteria [1]; (2) patients underwent, for at least 4 weeks before, a stable dose of disease-modifying antirheumatic drugs; this period was necessary to achieve the anticipated effects of medication on joint pain and disease activity; (3) absence of early RA (disease duration <2 years); (4) diagnosis of post-menopausal status [53]; (5) absence of early menopause [54]; (6) absence of an unstable heart condition, chronic obstructive pulmonary disease or cancer; (7) absence of prosthetics in the lower limb joints; (8) nonparticipation in any kind of exercise programme in the last 3 months; and (9) documented ability to walk barefoot and unassisted for >7 m (without current walking aids).

The selected patients were allocated to the exercise group (EG) or to the control group (CG). A power analysis using GPower 3.0.10 software was performed, indicating the need of a sample of 51 subjects in each group, for an independent-samples t-test, to reach a power of 0.8, an effect size of 0.5 with the significance level adjusted to 0.05. Despite the volunteering interest for the study, some patients had logistical difficulties to move to the training centre. Therefore, to reach the greatest possible sample, the allocation process in groups cannot be random. Consequently, this process was defined as following: whenever as possible, the patients were allocated to EG until an n = 15 was attained; the patients who did not have the possibility to meet the workout schedule in EG but had in CG, were allocated to CG; then, the selected patients were allocated to CG, adding to prior allocated patients. Thus, 15 patients were allocated to EG and 12 to CG. The patients read and signed an informed consent form before their participation in the study.

2.2 Exercises programmes

EG' subjects accomplished a proprioceptive exercises programme: 12 weeks; 3 workouts/week; 30 min/workout – 25 min of proprioceptive exercises and 5 min of stretching exercises (15 s/exercise). Proprioceptive exercises were specially designed to improve lower limbs movements, according to the description framework defined in introduction. These exercises can be viewed at http://pera.ulusofona.pt/exercise-programs/exercise-group/ and **Figure 1** presents an example.

An expert of the health and exercise field controlled just one subject in each individual workout (one-on-one session). This expert, who was not blind concerning allocation process, selected the proprioceptive exercises for all subjects (from the defined exercises). The selection of each exercise was made according to its level of complexity and each subject's capacity to perform the exercise. Exercise complexity was increased along the programme period (whenever the exercise was easily performed by the subject). 3 sets of 3 repetitions were performed in each exercise (performed under conditions without fatigue).

The selection of exercises for the CG programme presupposed that these exercises should not have any influence in the evaluated parameters. Thus, CG' subjects accomplished the following programme: 12 weeks; 1 workout every two weeks; 30 min/workout. Each session was composed by stretching exercises for trunk and

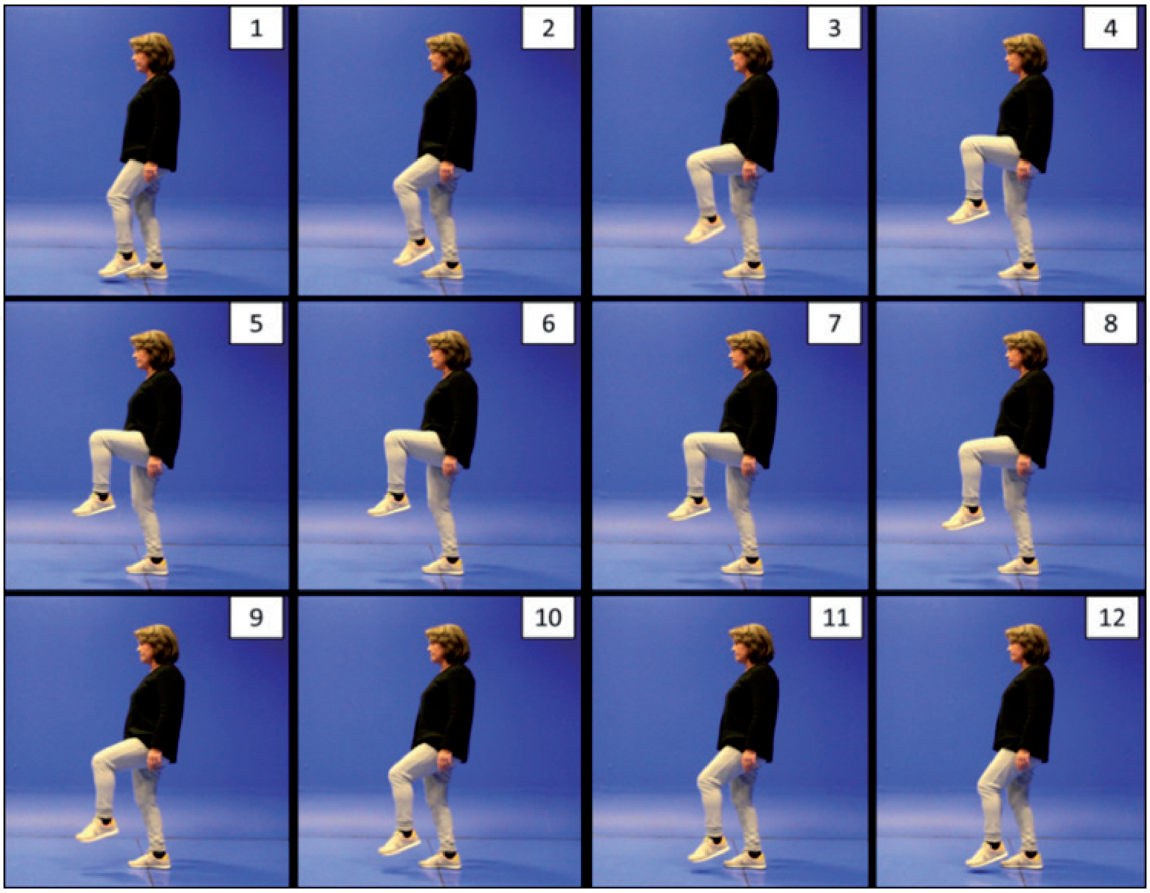

Figure 1.
Example of an exercise used in exercise group (exercise goal: Improve proprioception related to postural stability and local motor control – Lower limb joints of the support leg and hip of the swing leg; exercise description: in single leg stand position, performed flexion and extension of the swing leg hip).

upper limbs (15 s/exercise). At http://pera.ulusofona.pt/exercise-programs/control-group/ are presented these exercises. The training sessions in this group were also performed individually (one-on-one).

2.3 Assessment of disease activity

The Disease Activity Score–28 joints (DAS-28) was used to assess disease activity. DAS-28 score was calculated from: number of swollen and tender joints; visual analogue scale (VAS) to assess global health; and erythrocyte sedimentation rate [55]. One experienced rheumatologist evaluated the number of swollen and tender joints and applied the VAS. Erythrocyte sedimentation rate was assessed in a laboratory. The experienced rheumatologist and the laboratory were blind in relation to allocation process. Although the emphasis of the exercise programme was on lower limbs, most joints included in DAS-28 were located in the upper limbs. Therefore, the number of swollen or tender lower limb joints was also used to assess disease activity. To complement the aforementioned data, subjects answered to a VAS to measure pain perception regarding previous day [56]. This VAS is completed in a comprehensive way to the subjects: at the beginning of every workout session a horizontal straight line of 100 mm was presented in a white paper; the end anchors of the line were labeled as "no pain" on one end and "pain as bad as it could possibly be" on the other end; subjects responded to the VAS by placing a mark through the line already defined; this mark represented the subject's subjective pain perception regarding previous day. The VAS was scored by measuring the distance, in millimeters, between the anchor end labeled as "no pain" and the subject's mark on the line.

The demographic characteristics as well as reproductive and medical history of each subject were also collected by the experienced rheumatologist (age, body mass, height, duration of menopause, nature of menopause, disease duration, and pharmacological therapies).

2.4 Gait biomechanical assessment

An optoelectrical 3D motion analysis was used to assess gait biomechanical parameters. The Vicon® Motion Capture MX System (VICON Motion Systems, Oxford, UK) composed by 9 MX infrared cameras (7 × 1.3 MP; 2 × 2.0 MP), was synchronized with a force plate (model BP400600, AMTI, Watertown, MA, USA).

Each trial session had distinct parts: laboratory preparation, subject preparation, and data collection. The laboratory preparation included the calibration of the system made in accordance with the Vicon® technical specifications. Kinematic data was recorded at 200 Hz and ground reaction force data at 1000 Hz.

Subject preparation started with the collection of anthropometric data and the placement of 39 spherical reflective markers (9.5 mm diameter) that compose the Plug-In Gait Full-Body model (VICON Motion Systems, Oxford, UK). To assure the same measure and marker placement criteria, these tasks were performed by the same team researcher, who was not blind to the allocation process. The collection of the anthropometric data was carried out using a SECA 764 station (Hamburg Germany) and Siber-Hegner instruments (Siber & Hegner, Zurich, Switzerland).

Kinematic and kinetic data was recorded using the Vicon Nexus software (version 1.7.1). The test protocol used the guidelines specified in previous studies [14, 17]: (1) subjects walked barefoot in a gait corridor of 7 m long and 2 m wide, on which the force platform was mounted; (2) at the end of the corridor, the subjects turned around; (3) subjects were asked to walk at a natural and self-selected speed – representing the most comfortable walking speed that minimized possible discomfort that could have been caused if a pre-determined speed was determined [57] and minimized the induction of subjects into a transitioning stage, that is, a stage marked by an increased variability [58]; (4) seven valid trials of the gait stance phase were collected for each foot (trials were considered valid only when one foot stepped entirety on the force plate; this information was not given to the subjects to avoid changes in individual gait patterns); and (5) to avoid gait performance deterioration related to fatigue, subjects rested for 2 min by sitting on a chair every 20 trials.

All trials were processed using the Vicon Nexus software (version 1.7.1) and a quintic spline routine (Woltring filtering) was applied. The next gait biomechanical parameters were evaluated in the stride that started at heel strike on force plate: gait speed (m/s) – determined as described in a previous study [59]; stance phase time (s); time of the controlled plantar flexion sub-phase (s); time of the controlled dorsiflexion sub-phase (s); time of the powered plantar flexion sub-phase (s); ankle angular position in sagittal plane at the – heel strike (°), final of the controlled plantar flexion sub-phase (°), final of the controlled dorsiflexion sub-phase (°), toe off (°) – in these four angular positions, positive values means dorsiflexion and negative values means plantar flexion; ankle angular displacement along the – controlled plantar flexion sub-phase (°), controlled dorsiflexion sub-phase (°), and powered plantar flexion sub-phase (°); ankle moment of force peak in sagittal plane (Nm/kg); and ankle power peak (W/kg).

2.5 Assessment of body composition

For this study, an octopolar bioimpedance spectroscopy analyzer (InBody 720, Biospace, Korea) was used to assess body composition. This equipment analyses independently five body sections (i.e., trunk, both upper limbs, and both lower limbs). In a previous study [60], the accuracy of InBody 720 was tested using energy X-ray absorptiometry as a reference standard. Data revealed, in females, excellent agreements between InBody 720 and dual-energy X-ray for the quantification of the lower limb muscle mass (intraclass correlation coefficient ≥ 0.83) and percentage of fat mass (intraclass correlation coefficient = 0.93). Therefore, in this study were evaluated the muscle mass values (kg and % of total body mass) and the percentage of fat mass (%). These data was included in this chapter in order to improve the quality of the discussion. These assessments were carried out in accordance with the procedures presented in the equipment user manual [61].

2.6 Statistical analyses

In patients with RA, right and left lower limb joints can be differently affected during the course of the disease. Accordingly, intra-individual differences between lower limbs of post-menopausal women with RA, concerning ankle kinematics and kinetics, were observed in a prior study [14]. Consequently, randomly selected and measured only one lower limb per subject could conduct to loss of valuable information. According to literature [62], the statistical analyses should consider both sides for analyses when right and left lower limbs are independent. Therefore, each limb/ankle/foot dataset was independently considered for the statistical analyses. To this end, the mean and the coefficient of variation (CV) of the biomechanical parameters of each ankle/foot were calculated (from the seven trials collected for the contact of each foot on force plate). These data were inserted in the SPSS software for Windows, version 17 (SPSS, Inc., Chicago, IL), in order to perform the statistical analyses. Variability was studied through the CV.

The t-test's significance level can be almost exact for sample sizes greater than 12, even if the distribution was not normal [63]. Therefore, a two-tailed paired-samples t-test was used to compare baseline and post intervention in each group. For the purpose of comparison between groups after intervention, the differences between baseline and post intervention were viewed as variables. A two-tailed independent-samples t-test was used to compare groups at baseline and post intervention. Differences were considered statistically significant at p values <0.05.

3. Results

One withdrawal was registered in EG: the post-menopausal woman with RA failed to meet the training schedule, precluding her inclusion in statistical analyses. Thus, in the EG only fourteen post-menopausal women with RA were included in the statistical analyses. In EG and CG, the rate of adherence to the programme was 86.1 ± 10.5% and 95.8 ± 27.5%, respectively.

3.1 Clinical, demographic, and body composition data

Table 1 presents the descriptive statistics of the clinical, demographic, and body composition data for EG and CG, at baseline and post exercises programmes. In these parameters no statistically significant intergroup difference was found at baseline.

Most of the post-menopausal woman with RA, in both groups, presented at least one swollen or tender lower limb joint: one in EG and two in CG had no swollen or tender joints to report. One post-menopausal woman with RA in EG and two in CG had an induced menopause (i.e., bi-lateral oophorectomy) – remaining women had a natural menopause. Furthermore, two post-menopausal women with RA in each

Parameters	**EG (n = 14)**			**CG (n = 12)**		
	Baseline mean (sd)	**Post mean (sd)**	**p value**	**Baseline mean (sd)**	**Post mean (sd)**	**p value**
Age (years)	62.2 (8.8)		—	67.8 (6.6)		—
Disease duration (years)	9.3 (9.5)		—	11.6 (9.9)		—
Duration of menopause (years)	14.8 (8.3)		—	19.0 (9.6)		—
DAS-28 score	4.6 (1.5)	4.0 (1.3)	0.059	4.6 (1.2)	4.2 (0.9)	0.097
Number tender or swollen joints[1]	9.0 (10.3)	6.4 (9.1)	0.069	6.1 (5.2)	3.8 (5.5)	0.084
VAS (mm)	47.0 (18.2)	21.1 (13.9)	0.000	53.0 (14.3)	47.4 (19.8)	0.348
Body mass (kg)	67.5 (15.3)	66.4 (14.6)	0.023	63.2 (10.0)	63.7 (10.1)	0.168
Height (m)	1.53 (0.06)		—	1.52 (0.05)		—
Body mass index (kg/m^2)	29.0 (5.9)	28.5 (5.7)	0.025	27.4 (4.3)	27.6 (4.4)	0.140
Fat mass (%)	36.9 (7.7)	36.1 (8.1)	0.508	34.9 (7.1)	36.0 (6.2)	0.381
Lower limbs muscle mass (kg)	12.0 (0.8)	12.0 (0.9)	0.926	11.4 (0.9)	11.4 (1.0)	0.873
Lower limbs muscle mass (%)	18.2 (2.5)	18.5 (3.1)	0.417	18.2 (2.1)	18.4 (2.5)	0.739

[1] *lower limb joints.*

CG – control group; DAS-28 – Disease Activity Score (28 joints); EG – exercise group; p value – differences between baseline and post intervention were considered statistically significant at p values <0.05; sd – standard deviation; VAS – visual analogue scale to measure pain perception in relation to previous day.

Table 1.
Clinical, demographic, and body composition data at baseline and post intervention.

group were undergoing hormone therapy. Eleven post-menopausal women with RA in EG and nine in CG were using glucocorticoids.

Between baseline and post exercises programmes, both groups presented a tendency to reduction in the DAS-28 score, as well as in the number of tender or swollen lower limb joints. Between the first and last workout session, the EG' subjects presented a decrease of the value of the VAS to measure pain perception regarding previous day ($p < 0.001$). **Figure 2** shows this reduction along the proprioceptive exercises programme sessions. In the CG, no statistically significant difference between the first and last workout session was observed.

Concerning body composition, no differences were observed between baseline and post exercises programmes in both groups.

3.2 Gait biomechanical data

Table 2 describes the gait biomechanical data at baseline and post exercises programmes. At baseline, no statistically significant intergroup difference was found. **Figure 3** presents the curves of the ankle power and ankle moment of force of both groups, during the stance phase.

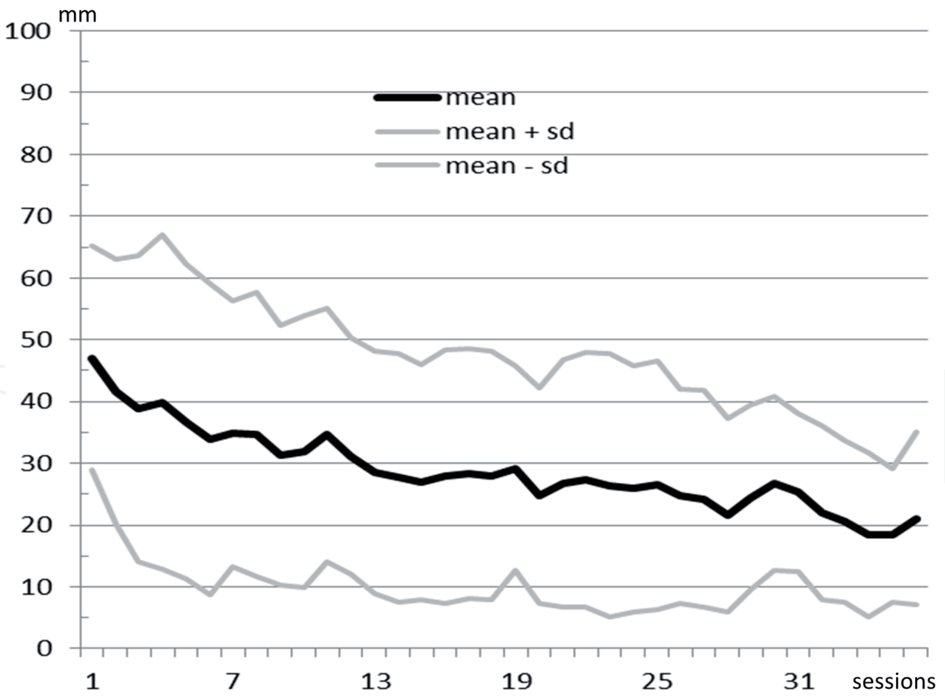

Figure 2.
Mean ± standard deviation curves of the visual analogue scale to measure pain perception regarding previous day [56] – Answered by EG' subjects at each workout session (0–100 mm).

Parameters	**EG (n = 28)**			**CG (n = 24)**			**p value**
	Baseline mean (sd)	**Post mean (sd)**	**Δ mean (sd)**	**Baseline mean (sd)**	**Post mean (sd)**	**Δ mean (sd)**	
Gait speed (m/s)	0.97 (0.20)	1.01 (0.18)	0.05 (0.10)[†]	0.96 (0.24)	0.95 (0.24)	−0.01 (0.07)	0.028[*]
Stance phase time (s)	0.70 (0.08)	0.67 (0.08)	−0.02 (0.05)[†]	0.71 (0.11)	0.72 (0.11)	0.01 (0.08)	0.007[*]
Controlled plantar flexion sub-phase							
Time (s)	0.06 (0.01)	0.06 (0.01)	0.00 (0.01)	0.05 (0.01)	0.05 (0.01)	0.00 (0.00)	0.701
Ankle angular position at beginning of phase (°)	−5.1 (4.0)	−4.3 (3.5)	0.7 (3.0)	−4.9 (3.7)	−4.4 (4.3)	0.6 (2.3)	0.846
Ankle angular position at end of phase (°)	−9.2 (3.6)	−8.9 (3.2)	0.2 (3.2)	−8.5 (4.0)	−8.4 (5.3)	0.2 (2.5)	0.998
Ankle angular displacement (°)	4.1 (2.6)	4.6 (2.3)	0.5 (1.6)	3.6 (1.8)	4.0 (2.5)	0.4 (1.3)	0.803
Controlled dorsiflexion sub-phase							
Time (s)	0.49 (0.07)	0.47 (0.08)	−0.02 (0.04)[‡]	0.49 (0.11)	0.50 (0.11)	0.00 (0.03)	0.027[*]
Ankle angular position at beginning of phase (°)	−9.2 (3.6)	−8.9 (3.2)	0.2 (3.2)	−8.5 (4.0)	−8.4 (5.3)	0.2 (2.5)	0.998

Parameters	EG (n = 28)			CG (n = 24)			p value
	Baseline mean (sd)	**Post mean (sd)**	**Δ mean (sd)**	**Baseline mean (sd)**	**Post mean (sd)**	**Δ mean (sd)**	
Ankle angular position at end of phase (°)	13.1 (3.3)	11.9 (3.9)	−1.1 (3.5)	13.6 (3.8)	13.8 (3.4)	0.2 (1.9)	0.124
Ankle angular displacement (°)	22.3 (3.5)	20.9 (4.7)	−1.4 (3.7)	22.1 (5.6)	22.1 (6.1)	0.0 (2.6)	0.135
Powered plantar flexion sub-phase							
Time (s)	0.15 (0.02)	0.15 (0.03)	0.00 (0.02)	0.16 (0.03)	0.17 (0.03)	0.01 (0.03)†	0.060
Ankle angular position at beginning of phase (°)	13.1 (3.3)	11.9 (3.9)	−1.1 (3.5)	13.6 (3.8)	13.8 (3.4)	0.2 (1.9)	0.124
Ankle angular position at end of phase (°)	−9.3 (7.1)	−10.3 (6.0)	−1.1 (4.6)	−8.6 (6.7)	−9.4 (6.9)	−0.8 (3.5)	0.793
Ankle angular displacement (°)	22.4 (6.2)	22.2 (5.3)	−0.1 (4.6)	22.2 (6.4)	23.1 (6.9)	0.9 (3.9)	0.372
Ankle moment of force peak (Nm/kg)	1.12 (0.18)	1.16 (0.19)	0.03 (0.16)	1.08 (0.22)	1.09 (0.22)	0.01 (0.08)	0.587
Ankle power peak (W/kg)	2.34 (0.91)	2.60 (0.79)	0.27 (0.55)†	2.27 (1.10)	2.27 (0.98)	−0.01 (0.32)	0.043*

Ankle angular position is positive during dorsiflexion and negative during plantar flexion; CG – control group; EG – exercise group; p value – differences between groups concerning Δ; sd – standard deviation; Δ – difference between baseline and post exercises programme.
†p < 0.05 (differences between baseline and post intervention.
‡p < 0.01 (differences between baseline and post intervention).
**p < 0.05.*

Table 2.
Gait biomechanical data at baseline and post exercises programmes.

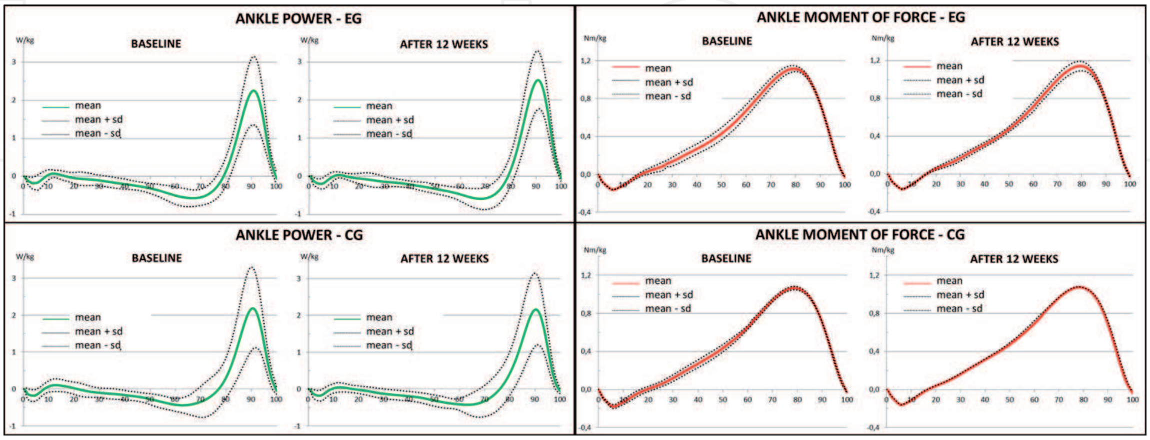

Figure 3.
Mean ± standard deviation curves of the ankle power and ankle moment of force of both groups, during the stance phase (normalized to 100% of the stance phase).

Between baseline and post intervention, EG' subjects yielded a higher gait speed (p = 0.027), a shorter stance phase (p = 0.014), a shorter controlled dorsiflexion sub-phase (p = 0.009), and a greater ankle power peak (p = 0.016). A trend towards reduction in ankle angular position at final controlled dorsiflexion sub-phase and in ankle angular displacement during controlled dorsiflexion sub-phase were observed in EG ($p = 0.090$ and $p = 0.059$, respectively). In the other gait biomechanical parameters of the EG' subjects, no statistically significant intragroup differences were found.

In CG, no statistically significant differences were found in gait biomechanical parameters after intervention, except for an increase of the time of powered plantar flexion sub-phase ($p = 0.043$).

Contrary to baseline, intergroup differences were found after intervention in gait speed, stance phase time, time of controlled dorsiflexion sub-phase, and ankle power peak ($p < 0.05$).

Variability of the gait biomechanical parameters showed no statistically significant intergroup or intragroup differences at baseline and post exercises programmes.

4. Discussion

A number of systematic reviews and meta-analysis [44–47] described the safety of using aerobic exercises, strength exercises, and the combination of both in patients with RA. Nonetheless, there was a need of researches that evaluate the effects of proprioceptive exercises on disease activity of patients with RA. Therefore, the first aim of this study was to describe the effects of a proprioceptive exercises programme on the disease activity of post-menopausal women with RA. Data from this study (DAS-28 and number of swollen or tender lower limb joints) showed no disease activity increase as a result of the exercise programme implementation; quite the reverse, data showed a trend towards reduction. Moreover, EG' subjects presented a reduction of the pain perception between the beginning and ending of the proprioceptive exercises programme. These results indicate that is safe to use proprioceptive exercises in post-menopausal women with RA.

A second aim was to evaluate the effects of the programme on ankle kinematics and kinetics of post-menopausal women with RA, during the gait stance phase. To the best of our knowledge, this was the first study that researched this topic in patients with RA, and specifically in post-menopausal women with RA. Data showed that a proprioceptive exercises programme had effects on ankle kinematics and ankle kinetics, as well as on gait speed, i.e.: higher gait speed, shorter stance phase and controlled dorsiflexion sub-phase, and higher ankle power peak. Otherwise, CG' subjects presented no changes post intervention. These results corroborated those of a prior study [50], which also found an increase of gait speed in elderly women after the participation in a proprioceptive training programme. Moreover, elderly also improved postural control after a proprioceptive exercises programme [49, 51]. However, none of them studied the effects of these programmes on ankle kinematics and kinetics during gait. As concluded in a recent study [14], post-menopausal women with RA should improve ankle kinematic and kinetic parameters during the propulsive phase of gait, which are important parameters for foot function, functional capacity, and fall prevention. Therefore, data presented in this study showed that a proprioceptive exercises programme had effects on those parameters, namely on the stance phase duration, controlled dorsiflexion sub-phase duration, and ankle power peak value. Thus, the improvement in foot function after the proprioceptive exercise programmes seems to point out that using this kind of interventions is indicated as an option for therapy in post-menopausal women with RA.

According to literature [14, 21–24], a lower ankle power and moment of force peaks were observed in patients with RA, and specifically in post-menopausal women with RA. Therefore, interventions to improve these gait biomechanical parameters are desirable, with exercises programmes being a possible option, namely proprioceptive exercise programmes. In the present study, post-menopausal women with RA yielded a higher ankle power peak as a result of the proprioceptive exercises programme; nonetheless, the ankle moment of force peak showed no change. Thus, the proprioceptive exercises programme enhanced joint power of the post-menopausal women with RA during the powered plantar flexion sub-phase, a parameter that may play an important role in the risk of fall. Otherwise, the inability of this programme to enhance muscle mass and ankle moment of force peak may indicate another reason is behind of the better performance during the powered plantar flexion sub-phase. According to a systematic review [38], there is evidence that proprioceptive exercises programmes can lead to improvements in proprioception and somatosensory function. According to this, we can speculate that the reason for a better performance was an improvement of proprioception and motor control as a result of the proprioceptive exercises programme.

Another aim was to evaluate the effects of the proprioceptive exercises programme on the ankle biomechanical variability. According to literature, an increased stride-to-stride variability was attributed to a probable loss of motor control [29] and post-menopausal women with RA yielded an increased variability of the ankle moment of force peak [14]. In this study, it was conjectured that the variability of the ankle moment of force peak could be decreased as consequence of the proprioceptive exercises programme; however, data showed no differences between pre and post intervention. Thus, another question arises, which can be answered by future research: “Could other kind of exercises programmes change variability of ankle kinematic and kinetic parameters during the gait stance phase?”

Strength training enhanced muscle mass of patients with RA [64, 65], however, the effect of a proprioceptive exercise programme on muscle mass was unknown. Between baseline and post exercise programmes, data showed no changes in low limbs muscle mass, pointing that these types of programmes had no effect on this parameter. Nonetheless, more research is required to clarify this question. On the other hand, post-menopausal hormone therapy, vitamin D and protein intakes, and menopause nature can influence muscle status [66, 67]. The use of hormone therapy could influence positively muscle status, whereas an induced menopause (e.g., bilateral oophorectomy) could be responsible of a greater impairment of muscle status. These parameters were not considered along the selection and allocation processes; nevertheless, data revealed that both groups of post-menopausal women with RA presented similar characteristics. Higher vitamin D and protein intakes could restrict muscle fiber atrophy; nonetheless, these variables were not evaluated in this study and thus, it can be considered as a limitation.

The presence of higher fat mass values could predispose to hypertension, diabetes, and risk for cardiovascular disease [68] and patients with RA showed high percentages of fat mass [69–72]. Fat tissue is an important font of inflammatory cytokines that could contribute to the systemic inflammation [72]. Following this deduction, it would be important to reduce fat mass in patients with RA, and to achieve this, physical exercise appears as an important strategy. However, the proprioceptive exercises programmes assessed in our study had no effect on fat mass of post-menopausal women with RA. To the best of our knowledge, this was the first study that researched this issue. Previous studies researched the effects of other types of physical exercise on fat mass of patients with RA. Two studies showed no change of the fat mass after strength training programmes [65, 73]. Otherwise, a combined strength and endurance training programme decreased the subcutaneous fat thickness and this should not be dissociated from the inclusion of aerobic exercises in the training programme [74]. Accordingly, aerobic exercises are the best option for decreasing fat mass [75]. The importance of proprioceptive exercises is recognized with the findings showed in the present study; however, as described in literature [64], an exercise programme for patients with RA must contain aerobic, strength, mobility and proprioceptive exercises to achieve all benefits.

According to the literature [47], exercises programmes for patients with RA should be cautiously designed to the individual. The methodology of our exercise programme followed this indication. However, according to a number of systematic reviews [44–48], most studies that evaluated the effects of physical exercise on patients with RA applied group training sessions in their programmes. Consequently, it is imperative to emphasize the kind of exercise programme used in the present research (an individualized and personalized exercise programme). In the present study, the one-on-one workout sessions could have contributed to the high adherence rates of the programmes and to the observed results. Moreover, the clinical community can easily apply a similar programme due to the type of equipment used, i.e., low-cost equipment.

In accordance with the aforementioned, the use of proprioceptive exercise in clinical practice with women with RA is suggested, especially in patients in the following situations: patients with low physical activity; after periods of immobility; in recovery phases from an active disease; in aftercare for joint replacement surgery (total hip or knee prosthesis); in elderly patients, those with rheumatoid cachexia, those with a history of falls; after the first fracture; and in patients with moderate to severe osteoporosis.

5. Conclusions

A proprioceptive exercises programme had effects on the ankle biomechanical performance of post-menopausal women with RA, during the gait stance phase: increasing ankle power peak and shortening controlled dorsiflexion sub-phase. The programme also increased gait speed and shortened stance phase, although it had no effects on body composition. Finally, it seems to be safe in post-menopausal women with RA.

Conflict of interest

The authors declare no conflict of interest.

Author details

Pedro Aleixo[1]*, Tiago Atalaia[2], José Vaz Patto[3] and João Abrantes[4]

1 Centre for Research in Sport, Physical Education, Exercise and Health,
Lusófona University, Lisbon, Portugal

2 Portuguese Red Cross Health School, Lisbon, Portugal

3 Portuguese Institute of Rheumatology, Lisbon, Portugal

4 Centre for Research in Applied Communication, Culture and New Technologies,
Lusófona University, Lisbon, Portugal

*Address all correspondence to: pedro.aleixo@ulusofona.pt

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