REV BRAS REUMATOL. 2016;xxx(xx):xxx–xxx

SOCIEDADE BRASILEIRA DE REUMATOLOGIA

REVISTA BRASILEIRA DE REUMATOLOGIA

www.reumatologia.com.br

Original article

Swiss ball exercises improve muscle strength and walking performance in ankylosing spondylitis: a randomized controlled trial

Marcelo Cardoso de Souza[a,b], *Fábio Jennings*[a], *Hisa Morimoto*[a], *Jamil Natour*[a,*]

[a] *Universidade Federal de São Paulo (Unifesp), Escola Paulista de Medicina (EPM), Disciplina de Reumatologia, São Paulo, SP, Brazil*
[b] *Universidade Federal do Rio Grande do Norte (UFRN), Faculdade de Ciências da Saúde do Trairí (Facisa), Curso de Fisioterapia, Santa Cruz, RN, Brazil*

ARTICLE INFO

Article history:
Received 12 January 2016
Accepted 28 April 2016
Available online xxx

Keywords:
Exercises
Resistance exercises
Swiss ball
Ankylosing spondylitis

ABSTRACT

Objective: The purpose was to evaluate the effectiveness of a progressive muscle strengthening program using a Swiss ball for AS patients.
Methods: Sixty patients with AS were randomized into the intervention group (IG) or the control group (CG). Eight exercises were performed by the IG patients with free weights on a Swiss ball two times per week for 16 weeks. The evaluations were performed by a blinded evaluator at baseline and after 4, 8, 12 and 16 weeks using the following instruments: the one-repetition maximum test (1 RM), BASMI, BASFI, HAQ-S, SF-36, 6-minute walk test, time up and go test, BASDAI, ASDAS, ESR and CRP dosage and Likert scale.
Results: There was a statistical difference between groups for: strength (1 RM capacity) in the following exercises: abdominal, rowing, squat, triceps and reverse fly ($p < 0.005$); 6-minute walk test ($p < 0.001$); timed up and go test ($p = 0.025$) and Likert scale ($p < 0.001$), all of them with better results for the IG. No differences were observed between the groups with respect to the functional capacity evaluation using the BASFI, HAQ-S, BASMI, SF-36, TUG, ASDAS, ESR and CPR dosage.
Conclusions: Progressive muscle strengthening using a Swiss ball is effective for improving muscle strength and walking performance in patients with AS.

* *Corresponding author.*
E-mail: jnatour@unifesp.br (J. Natour).

http://dx.doi.org/10.1016/j.rbre.2016.09.009

Please cite this article in press as: Souza MC, et al. Swiss ball exercises improve muscle strength and walking performance in ankylosing spondylitis: a randomized controlled trial. Rev Bras Reumatol. 2016. http://dx.doi.org/10.1016/j.rbre.2016.09.009

Exercícios na bola suíça melhoram a força muscular e o desempenho na caminhada na espondilite anquilosante: ensaio clínico randomizado

Palavras-chave:
Exercícios
Exercícios resistidos
Bola suíça
Espondilite anquilosante

RESUMO

Objetivo: Avaliar a efetividade de um programa de fortalecimento muscular progressivo com o uso de uma bola suíça em pacientes com espondilite anquilosante (EA).

Métodos: Sessenta pacientes com EA foram randomizados em grupo intervenção (GI) ou grupo controle (GC). Os pacientes com EA fizeram oito exercícios com pesos livres em uma bola suíça duas vezes por semana durante 16 semanas. As avaliações foram feitas por um avaliador cego no início do estudo e após quatro, oito, 12 e 16 semanas com os seguintes instrumentos: teste de uma repetição máxima (1 RM), Basmi, Basfi, HAQ-S, SF-36, teste de caminhada de seis minutos, *Timed up and go test*, Basdai, Asdas, dosagem de VHS e PCR e escala de Likert.

Resultados: Houve uma diferença estatisticamente significativa entre os grupos em relação à força (capacidade no teste de 1 RM) nos seguintes exercícios: abdominal, remada, agachamento, tríceps e crucifixo invertido ($p < 0{,}005$); teste de caminhada de seis minutos ($p < 0{,}001$); *Timed up and go test* ($p = 0{,}025$); e escala de Likert ($p < 0{,}001$), todos com melhores resultados no GI. Não foram observadas diferenças entre os grupos em relação à avaliação da capacidade funcional com Basfi, HAQ-S, Basmi, SF-36, TUG, Asdas, VHS e dosagem de PCR.

Conclusões: O fortalecimento muscular progressivo com uma bola suíça é efetivo em melhorar a força muscular e o desempenho na caminhada em pacientes com EA.

Introduction

Ankylosing spondylitis (AS) is an inflammatory disease that affects the axial skeleton and causes low back pain and functional impairment. The disease causes inflammation and pain in the spine and joints, which reduces physical activity and spinal mobility and causes fatigue, stiffness, sleep disorders and depression.[1] Exercises are important to maintain or improve spinal mobility and physical fitness as well as to reduce pain and are included in evidence-based recommendations for the management of AS.[2]

One study showed that weakness of peripheral muscles of the limbs (specially the quadriceps) could be one of the most important determinant of exercise intolerance in patients with AS. Also, the study concluded that muscle deconditioning is one of the most important factor for the reduction in aerobic capacity, suggesting the importance of muscle strengthening exercises in these patients, in addition to aerobic training.[3]

Resistance exercises are currently used in several studies.[4] They can be performed using free weights, resistance bands or weight machines.[5] Exercise that use the Swiss ball differed from other resistance exercise because it recruits the muscles responsible for spine stabilization during movement.[6] Musculoskeletal and cardiovascular safety of resistance training have also been demonstrated, even in the face of co-morbidities. Currently, there is evidence to justify the use of these exercises for health promotion, rehabilitation and therapeutic purposes.[4,7,8]

Despite the recognized importance of exercise as part of a treatment plan for patients with AS, the benefit of specific exercise programs have not been established in the literature.[9]

In a systematic review of the literature, the authors reported difficulty in performing a meta-analysis due to heterogeneity of the studies. In this review, it was shown that there is moderate evidence on the effects of exercise in improving functional capacity, disease activity and chest expansion when compared to a control group without exercise. The authors conclude that literature has not established which exercise protocol is more effective in AS.[10]

Muscle strengthening exercises have been studied in five other trials in AS patients. In these studies, the strengthened muscles were the legs, trunk, arms, back and abdominal exercises. Most of these trials fail to not describe the methodology used to perform the strengthening exercises as: sets, number of repetitions, load maximum calculation, frequency per week, progression of loads and duration of muscle strengthening program.[11–15]

Resistance exercises with the aid of unstable surfaces such as a Swiss ball are hypothesized to improve the functional capacity of patients because this workout affects other aspects of physical fitness such as balance and proprioception.

The aim of this study was to evaluate the effectiveness of muscle strengthening exercises with a Swiss ball primarily in the functional capacity and, secondarily, in muscle strength, disease activity, spinal mobility, performance in walking and quality of life in patients with AS.

Please cite this article in press as: Souza MC, et al. Swiss ball exercises improve muscle strength and walking performance in ankylosing spondylitis: a randomized controlled trial. Rev Bras Reumatol. 2016. http://dx.doi.org/10.1016/j.rbre.2016.09.009

Material and methods

Population

This study is a randomized controlled trial with a blind evaluator and 16 weeks of follow-up. Sixty patients of both genders, between 18 and 60 years old, who had been diagnosed with AS by a rheumatologist according to the modified New York criteria[16] were selected by personal invitation during routine visits in a outpatient clinic of a university hospital (Universidade Federal de São Paulo). The study was approved by the ethics committee of the institution (CEP 0038/11) and was registered (*Clinicaltrials.gov*: NCT01351311).

The inclusion criteria were as follows: an established diagnosis of AS; a Steinbrocker functional class of I-II; for patients that were using medication the dosage should be stable – disease-modifying anti-rheumatic drug (DMARD) for at least three months and NSAIDs and/or corticosteroids for at least four weeks. The patients who were not using any medication for AS, should be on this condition for at least three months.

Patients with uncontrolled hypertension, a history of coronary artery disease, a history of syncope or arrhythmias induced by exercise, decompensated diabetes mellitus, severe psychiatric disorders, fibromyalgia, a more disabling medical condition than AS, a history of regular exercise of at least 30 min two times a week in the last 3 months, and any condition that could prevent the patient from performing exercises in the last three months, were excluded.

A computer-generated randomization list was utilized to randomly allocate patients into intervention (IG) or control (CG) groups and a concealed randomization with an opaque sealed envelope was performed.

Intervention

Intervention group

The IG performed resistance exercises on a Swiss ball in group of a maximum of 4 patients under supervision of a trained physiotherapist. The exercises protocol is described in Fig. 1. The ball size was chosen according to patient height. For 16 weeks, these patients performed eight exercises twice a week in 50-minute sessions. The loads were assessed at baseline and re-assessed after 4, 8, 12 and 16 weeks to evaluate the progression of the loads. The loads were evaluated by the one-repetition maximum (1 RM) test, where 1 RM is the maximum load supportable in the execution of a single movement.

All the exercises were performed in three sets of 10 repetitions. The weight progression was as follows: in weeks 0 through 4, the exercises were performed with 50% of the 1RM; in weeks 4 through 12, the exercises were performed with 60% of the 1RM; and in weeks 12 through 16, the exercises were performed with 70% of the 1RM. We adopted a 2-minute recovery period between the sets.[4]

The IG patients underwent muscle-strengthening exercises with the aid of a ball and dumbbells, as described in Table 1. All the exercises required simultaneous muscle contraction of the latissimus dorsi, abdominal, paraspinal, gluteus, quadriceps and hamstring muscles to maintain stability on the ball.[6]

Control group

The CG remained with medical treatment only, and the identical treatment was offered to them after the end of the study.

Outcomes

The primary outcome is the BASFI (Bath Ankylosing Spondylitis Functional Index). Patients were evaluated before randomization at baseline (T0) after 4 (T4), 8 (T8), 12 (T12) and 16 (T16) weeks. The following outcomes were evaluated by a blinded evaluator:

- BASFI (Bath Ankylosing Spondylitis Functional Index); is 10 item index that evaluate the functional capacity in performing daily activities of patients with AS. The average of the results of the ten scales is the BASFI score (0–10), with higher values indicating greater impairment in functional capacity.[17]
- HAQ-S (Health Assessment Questionnaire for Spondyloarthritis); to assess the physical functioning. The measure includes items concerning dressing, arising, eating, walking, hygiene, reaching, gripping, and errands and chores taken from the disability index of the HAQ, and an additional 5 specific items concerning neck function and static posture (driving a car, using a rear-vision mirror, carrying heavy groceries, sitting for long periods, and working at a desk). There are 25 items divided in 10 domains. The final score is the result of the sum of the average scores of the ten domains, ranging from 0 to 3.[18]
- 6-minute walking test (6MWT) that is a functional test that assess distance walked over 6 min in a 22-meter indoor track.[19]
- Timed up and go test (TUG) that is a functional test that aims to assess mobility and balance. Measure the time in seconds for a person to rise from sitting from a standard arm chair, walk 3 m, turn, walk back to the chair, and sit down. The person wears regular footwear and customary walking aid.[20]
- One repetition maximum test (1 RM) was used for to evaluate the muscle strength, 1-RM represented the maximum weight that the patient can lift in one repetition.[8]
- BASDAI (Bath Ankylosing Spondylitis Disease Activity Index) is the gold standard for measuring and evaluating disease activity in AS. Patients answered 6 questions pertaining to the 5 major symptoms of AS: fatigue, spinal pain and joint pain/swelling, areas of localized tenderness, morning stiffness duration, and morning stiffness severity. The final score ranges from 0 to 10 with higher score suggesting suboptimal control of disease.
- BASMI (Bath Ankylosing Spondylitis Metrology Index) which consists of five steps: cervical rotation, tragus to wall distance, lumbar side flexion, modified Schober's and intermalleolar distance. Patients repeated each measurement three times and the best of them was used. Each is allocated on a numerical scale from zero to ten and the final score of BASMI is the arithmetic mean of the five values, the end result may vary from 0 to 10.[21]
- Chest expansion was used to assess chest mobility. Using a tape the circumference of the patient's chest was measured at the level of the 4th intercostal space. Patients were asked

Please cite this article in press as: Souza MC, et al. Swiss ball exercises improve muscle strength and walking performance in ankylosing spondylitis: a randomized controlled trial. Rev Bras Reumatol. 2016. http://dx.doi.org/10.1016/j.rbre.2016.09.009

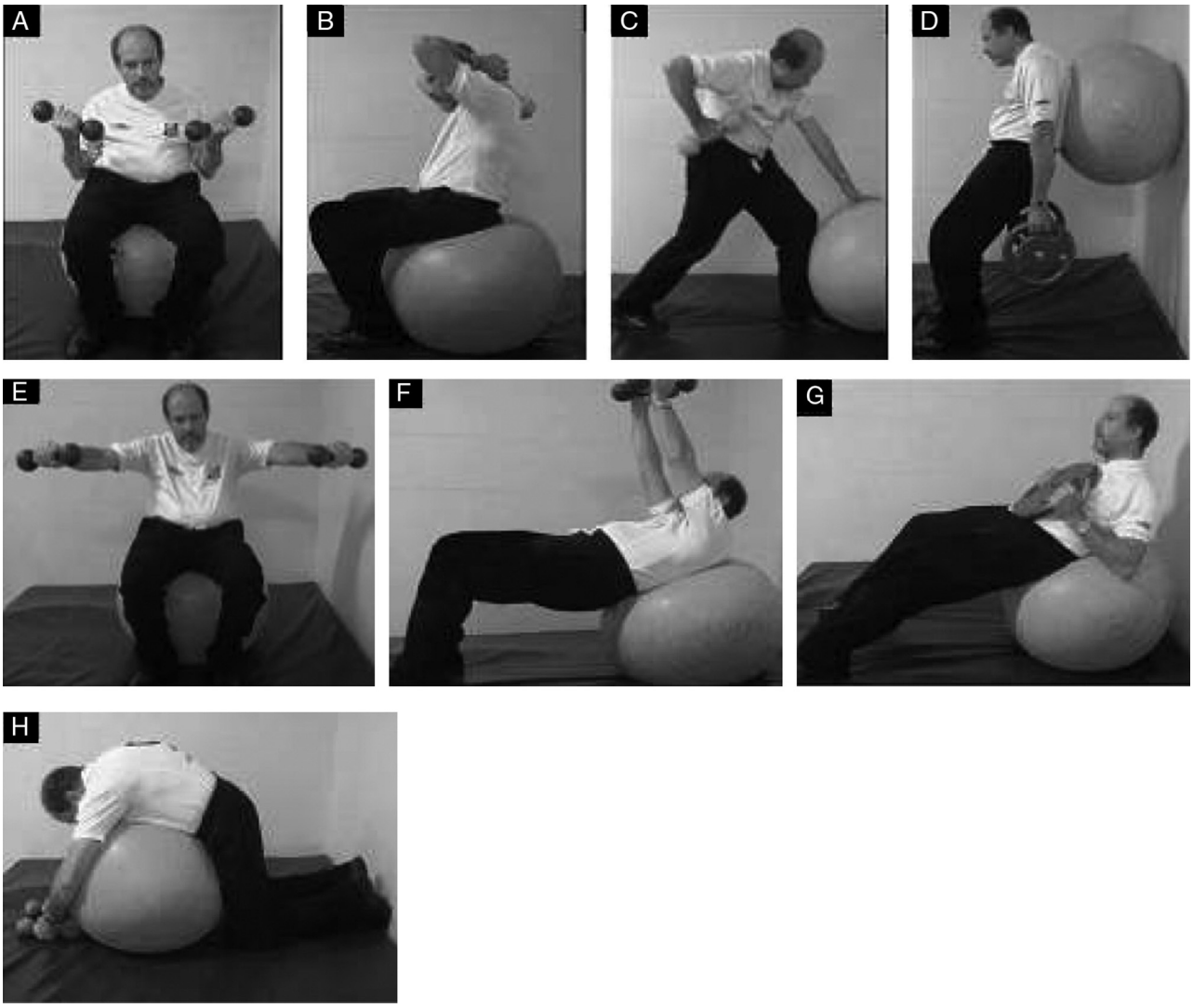

Fig. 1 – (A) Biceps – sitting on the ball, flexes and extends the forearm against resistance of free weight. Major muscles acting: biceps, radial brachiobasilic; (B) triceps – sitting on the ball, hold the dumbbell with both hands, raise your arms so they are perpendicular to the ground and performs flexion and extension of the forearm. Major muscles acting: triceps, deltoid; (C) rowing – standing position, with one leg up and over the ball and the contralateral limb in extension and the upper performs motion similar to rowing. Major muscles acting: teres major, teres minor, rhomboids and serratus anterior; (D) squat – standing position, with the support of the ball in the lumbar, performs squat movement with weights in hands. Major muscles acting: quadriceps, hamstrings, gluteus maximus and middle, rectus abdominis and latissimus dorsi; (E) lateral rise – sitting on the ball, makes abduction of the upper limb against resistance. Major muscles acting: clavicular e acromial deltoid; (F) crucifix – supine on the ball, with thoracic and lumbar spines on the ball, performs the abduction movement of the upper limbs. Major muscles acting: pectoralis major, long head of the biceps; (G) abdominal – supine on the ball, with a load on the pectoral region and lumbar spine on the ball, performs flexion of the trunk. Major muscles acting: rectus abdominis, external and internal oblique, gluteus; (H) reverse crucifix – prone on the ball, kneeling on a pillow, performs full extension of the arms. Major muscles acting: posterior deltoid, teres major, teres minor, trapezius.

to inspire and exhale maximally using standard breathing instructions and the greater excursion in cm recorded.[22]

- The SF-36 Health Survey was used to evaluate the quality of life. With overall scores ranging from 0 to 100 (higher scores denote better general health).[23]
- The ASDAS-CRP/ESR (Ankylosing Spondylitis Disease Activity Score) the C-Reactive Protein (CRP) and the erythrocyte sedimentation rate (ESR) were used to assess the disease activity; the ASDAS determines disease activity, using the scores (on a scale of numerical measure of 0–10) of back pain, duration of morning stiffness, global assessment by the patient, pain/swelling in peripheral joints and also the PCR doses (mg/L) or ESR (mm/h). The values are put into an equation to obtain the final score.[24]
- Patient satisfaction with the treatment (Likert scale) – the patients were asked about: "How they felt after treatment?"

Please cite this article in press as: Souza MC, et al. Swiss ball exercises improve muscle strength and walking performance in ankylosing spondylitis: a randomized controlled trial. Rev Bras Reumatol. 2016. http://dx.doi.org/10.1016/j.rbre.2016.09.009

Table 1 – Clinical and demographic characteristics of the patients with AS (*n* = 60).

Variables	Intervention group (*n* = 30)	Control group (*n* = 30)	*p*
Age – years (mean (SD))	45 (9.8)	43.8 (10.2)	0.663[a]
Gender (f:m)	07:23	09:21	0.559[b]
Time since diagnosis – years (mean (SD))	8.8 (6.6)	9.6 (7.8)	0.830[c]
Drugs – n (%)			
No drugs	4 (13.8)	1 (3.3)	0.149[b]
NSAID continuous	7 (24.1)	9 (30)	0.613[b]
MTX	6 (20.7)	4 (13.3)	0.451[b]
SLZ	5 (17.2)	2 (6.7)	0.209[b]
TNF	10 (34.5)	13 (43.3)	0.728[b]

SD, standard deviation; MTX, methotrexate; SLZ, sulfasalazine; TNF, tumor necrosis factor.
[a] Student's *t*-test.
[b] Chi square test.
[c] Mann–Whitney test.

and can choose between five sentences as follows: 1 – much worse; 2 – a little worse, 3 – no change, and 4 – a little better; 5 – much better.[25]

- Anti-inflammatory and analgesic intake – the amount of medication used during the study was noted on a spreadsheet given to the patients.
- All instruments of assessment used in this study were translated and validated for the Brazilian version and following we explained when the outcomes were evaluated during the study: 1RM was evaluated in all evaluation times; patient satisfaction was evaluated at T4, T8, T12, and T16; BASFI, HAQ-S, 6MWT, TUG, BASMI, thoracic expansion, BASDAI and SF-36 were evaluated at T0, T8 and T16; ESR, CPR and ASDAS were evaluated at T0 and T16 and the anti-inflammatory and analgesic intake was evaluated at T16.

Statistical analysis

The sample size was calculated using the variable BASFI as the main variable of the study, and the standard deviation was 2.0 points.[26] We used a repeated-measure ANOVA as the statistical method for this analysis. For the determination of a minimal effect of 2.0 points, a 5% α error, 20% β error and SD (σ) of 2.0 points were established. Given a power of 80% and a 5% detectable significance difference equal to 2.0 in the range that BASFI measured three times over time in two independent groups, we found a sample of 27 patients in each group. Considering the possible dropouts, we randomized 60 patients.

The data were analyzed by SPSS software version 17.0 (Chicago, IL). The continuous variables between the two groups at baseline were compared using Student's *t*-test (for variables with normal distribution) and the Mann–Whitney test (for the variables with non-normal distribution). The categorical variables were compared using the chi-square test. To assess the response to intervention, the intention to treat analysis was used, with the last evaluation carried forward when necessary. The analysis of variance (ANOVA) with repeated measures was used to assess the response to therapy over time. The effect size was calculated between groups for variables that showed differences between groups at any time, with the confidence interval of 95%. The level of statistical significance was 5%.

Results

Fig. 2 shows the flowchart of the study. Three patients in the IG and 2 patients in the CG abandoned the study. The reasons were: loss of contact, pain exacerbation and rupture of calcaneus tendon in the IG and loss of contact in the CG.

The patients were homogeneous with respect to the demographic and clinical characteristics at baseline (Table 1).

We did not find statistical differences between the groups with respect to the functional capacity assessed by BASFI, HAQS and TUG. We found no differences in the assessment of

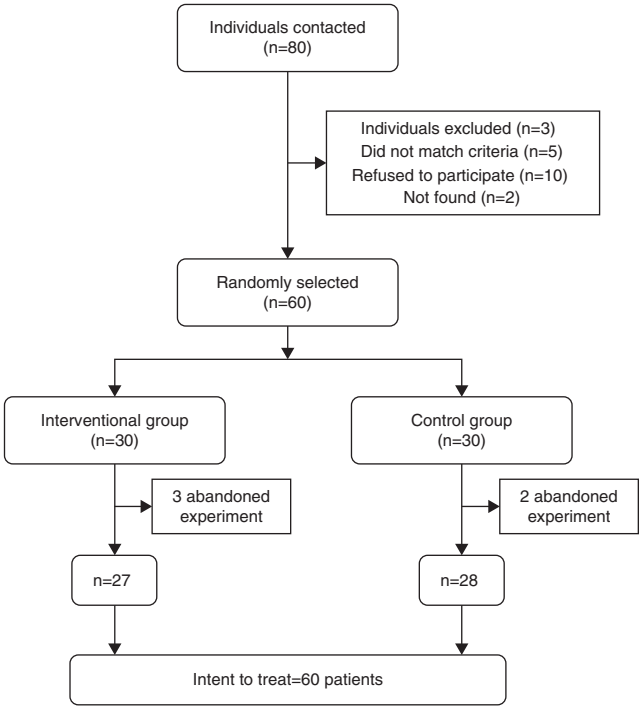

Fig. 2 – Flowchart of the study.

Please cite this article in press as: Souza MC, et al. Swiss ball exercises improve muscle strength and walking performance in ankylosing spondylitis: a randomized controlled trial. Rev Bras Reumatol. 2016. http://dx.doi.org/10.1016/j.rbre.2016.09.009

Table 2 – Evaluation of functional capacity, mobility, disease activity and analgesic/AINEs intake in both groups of patients with AS (*n* = 60) at different weeks.

Variables	Intervention group		Control group		*p interaction*[a]	*p intergroups*[a]	CV
Time	Mean	(SD)	Mean	(SD)			
BASFI					0.023		
T0	4.62	(2.49)	4.09	(2.40)		0.410	0.53
T8	3.88	(2.36)	3.99	(2.56)		0.872	0.60
T16	3.36	(2.16)	3.90	(2.6)		0.386	0.64
HAQ-S					0.131		
T0	0.79	(0.51)	0.75	(0.53)		0.637	0.64
T8	0.69	(0.46)	0.74	(0.51)		0.637	0.66
T16	0.58	(0.44)	0.70	(0.5)		0.637	0.75
BASMI					0.170		
T0	4.94	(2.09)	5.19	(2.04)		0.344	0.42
T8	4.90	(1.86)	5.44	(2.14)		0.344	0.37
T16	4.69	(1.94)	5.37	(2.2)		0.344	0.41
Thoracic expansion (cm)					0.768		
T0	3.33	(1.57)	3.50	(1.90)		0.939	0.47
T8	3.48	(1.83)	3.45	(2.02)		0.939	0.52
T16	3.45	(1.61)	3.41	(1.89)		0.939	0.46
6-minute walking test (m)					<0.001		
T0	447.43	(54.99)	435.43	(59.44)		0.424	0.12
T8	451.40	(51.52)	440.80	(51.96)		0.435	0.11
T16	464.43	(48.03)	427.20	(49.6)		0.005	0.10
Time up and go (s)					0.025		
T0	7.36	(1.68)	7.20	(1.60)		0.705	0.22
T8	6.48	(1.13)	6.62	(1.06)		0.621	0.17
T16	6.19	(1.16)	6.76	(1.31)		0.077	0.18
BASDAI					0.828		
T0	2.52	(1.65)	2.34	(2.26)		0.885	0.65
T8	2.09	(1.61)	2.01	(2.39)		0.885	0.77
T16	2.08	(1.84)	2.12	(2.4)		0.885	0.88
ASDAS-CRP					0.425		
T0	2.20	(0.91)	1.89	(1.00)		0.370	0.41
T16	1.93	(0.84)	1.86	(1.10)			0.43
ASDAS-ESR					0.075		
T0	2.23	(0.87)	2.11	(0.97)		0.474	0.39
T16	1.73	(0.70)	2.15	(1.25)			0.40
C-reactive protein (mg/dL)					0.351		
T0	6.53	(6.00)	4.70	(5.96)		0.063	0.91
T16	9.27	(13.50)	4.51	(6.75)			1.45
ESR (mm/h)					0.104		
T0	18.10	(13.23)	18.00	(12.27)		0.356	0.73
T16	13.31	(9.01)	18.71	(14.33)			0.67
NSAIDs							
T16	3.17	(5.86)	1.56	(4.88)		0.133[b]	1.84
Analgesic							
T16	1.97	(4.94)	2.19	(5.41)		0.749[b]	2.50

CV, coefficient of variation for intervention group; HAQ-S, Health Assessment Questionnaire for Spondyloarthritis; BASFI, Bath Ankylosing Spondylitis Functional Index; Basmi, bath ankylosing spondylitis metrology index; Basdai, Bath Ankylosing Spondylitis Disease Activity Index; ASDAS, Ankylosing Spondylitis Disease Activity Score; ASDAS PCR, ASDAS C-Reactive Protein; ASDAS VHS, ASDAS erythrocyte sedimentation rate.

[a] ANOVA test.

[b] Mann–Whitney test.

spinal mobility evaluated by BASMI and thoracic expansion. Statistical differences were found between the groups in the 6-minute walk test at week 16 ($p = 0.005$, coefficient of variation = 0.10). Regarding the disease activity, we found no statistical differences between the groups regarding BASDAI, ASDAS-CRP/ESR, CRP and ESR. There was no statistical significant difference between groups (Table 2) in the consumption of analgesics and NSAIDs.

Please cite this article in press as: Souza MC, et al. Swiss ball exercises improve muscle strength and walking performance in ankylosing spondylitis: a randomized controlled trial. Rev Bras Reumatol. 2016. http://dx.doi.org/10.1016/j.rbre.2016.09.009

Table 3 – Evaluation of muscle strength according to the exercises in both groups.

Exercise	Intervention group		Control group		*p interaction*[a]	*p intergroups*	CV
Time	Mean	(SD)	Mean	(SD)			
Biceps (kg)					0.041		
T0	6.47	(2.32)	6.57	(2.66)		0.878	0.35
T4	7.37	(2.60)	7.00	(2.53)		0.586	0.35
T8	7.63	(2.79)	7.20	(2.75)		0.550	0.36
T12	7.97	(2.64)	7.30	(2.56)		0.329	0.33
T16	8.43	(2.78)	7.43	(2.70)		0.166	0.32
Triceps (kg)					<0.001		
T0	6.90	(2.64)	7.23	(3.20)		0.664	0.38
T4	8.70	(3.28)	7.63	(3.62)		0.240	0.37
T8	9.27	(3.86)	7.93	(3.30)		0.160	0.41
T12	10.17	(4.16)	8.20	(3.39)		0.052	0.40
T16	11.07	(4.46)	8.57	(3.55)		0.021	0.40
Rowing (kg)					0.001		
T0	9.63	(3.18)	9.73	(3.04)		0.902	0.33
T4	11.10	(3.76)	10.70	(3.41)		0.670	0.33
T8	12.40	(4.25)	11.17	(3.92)		0.252	0.34
T12	19.47	(31.95)	11.27	(3.89)		0.024	1.64
T16	13.90	(4.03)	11.63	(3.58)		0.026	0.28
Squat (kg)					0.007		
T0	13.67	(5.90)	13.67	(6.06)		1.000	0.43
T4	16.53	(6.56)	14.97	(6.12)		0.347	0.39
T8	19.40	(6.78)	16.57	(6.57)		0.109	0.34
T12	20.50	(6.24)	16.97	(6.79)		0.042	0.30
T16	21.27	(7.47)	16.50	(6.89)		0.014	0.35
Lateral rise (kg)					<0.001		
T0	4.53	(1.84)	4.67	(2.14)		0.798	0.40
T4	4.97	(1.97)	5.00	(2.07)		0.950	0.39
T8	5.37	(1.91)	5.07	(2.20)		0.577	0.35
T12	5.73	(2.06)	5.20	(2.12)		0.332	0.35
T16	6.20	(2.21)	5.23	(2.28)		0.104	0.35
Crucifix (kg)					0.002		
T0	4.10	(1.92)	4.33	(2.01)		0.650	0.46
T4	4.73	(1.61)	4.60	(2.14)		0.788	0.34
T8	5.17	(1.88)	4.67	(1.92)		0.316	0.36
T12	5.70	(1.93)	4.70	(2.07)		0.060	0.33
T16	5.90	(2.04)	5.00	(2.38)		0.124	0.34
Abdominal (kg)					<0.001		
T0	16.63	(8.75)	17.63	(13.15)		0.731	0.52
T4	23.60	(12.10)	20.83	(12.53)		0.392	0.51
T8	28.33	(13.12)	21.67	(13.14)		0.056	0.46
T12	32.33	(15.26)	24.10	(13.08)		0.030	0.47
T16	39.33	(17.21)	26.33	(14.68)		0.003	0.43
Reverse crucifix (kg)					0.002		
T0	3.93	(1.44)	4.03	(1.45)		0.791	0.36
T4	4.75	(1.57)	4.27	(1.36)		0.213	0.33
T8	5.12	(1.67)	4.53	(1.59)		0.175	0.32
T12	5.33	(1.72)	4.67	(1.52)		0.120	0.32
T16	5.93	(1.88)	4.87	(1.61)		0.023	0.31

CV, coefficient of variation for intervention group.
[a] ANOVA test.

With regard to muscle strength, differences between the groups were observed, with improvement in the IG in the following exercises: triceps, rowing, squats, abdominal and reverse crucifix, as shown in Table 3.

Table 4 shows the domains of the SF-36, and no differences between the groups were observed in any domains of the questionnaire.

Statistical difference was observed between the groups on the Likert scale ($p < 0.001$). The intervention group showed a higher frequency of answers 4 (a little better) and 5 (much better), whereas the control group showed a higher frequency of answer 3 (no change).

The effect size (ES) was calculated for the variables that showed differences between groups at any time. In T16, we

Please cite this article in press as: Souza MC, et al. Swiss ball exercises improve muscle strength and walking performance in ankylosing spondylitis: a randomized controlled trial. Rev Bras Reumatol. 2016. http://dx.doi.org/10.1016/j.rbre.2016.09.009

Table 4 – Evaluation of the general quality of life using the SF-36 questionnaire in both groups of patients with AS.

Domains	Intervention group		Control group		*p interaction*[a]	*p intergroups*[a]	CV
Time	Mean	(SD)	Mean	(SD)			
Physical functioning					0.189		
T0	65.7	(23.2)	67.2	(23.2)		0.926	0.35
T8	69.2	(23.6)	71	(21.9)		0.926	0.34
T16	73	(18.3)	68.2	(26)		0.926	0.25
Role-physical					0.802		
T0	54.2	(47.4)	58.3	(47.5)		0.856	0.87
T8	63.3	(47.2)	60	(48.1)		0.856	0.69
T16	67.5	(42.1)	71.7	(42.9)		0.856	0.62
Pain					0.598		
T0	61.1	(19.8)	62.4	(25.4)		0.841	0.32
T8	66	(21.7)	61.7	(25.8)		0.841	0.32
T16	65.6	(19.4)	65.6	(27.5)		0.841	0.29
General health					0.365		
T0	44.7	(20.5)	46.2	(23.8)		0.718	0.45
T8	52.3	(21.3)	49.5	(23.5)		0.718	0.40
T16	51.8	(21.5)	47.3	(26.4)		0.718	0.41
Vitality					0.295		
T0	62.5	(25.2)	61.3	(33.6)		0.460	0.40
T8	69.5	(18.3)	64.8	(31.6)		0.460	0.26
T16	72.2	(17.8)	3.7	(30.9)		0.460	0.24
Social functioning					0.469		
T0	75.3	(24.9)	78.3	(24.2)		0.820	0.33
T8	81.6	(21.9)	78.3	(24.3)		0.820	0.26
T16	81.9	(21.7)	78.7	(26.5)		0.820	0.26
Role-emotional					0.866		
T0	60	(49.8)	75.5	(41)		0.161	0.83
T8	68.6	(44.6)	77.7	(40.4)		0.161	0.65
T16	72.2	(43.9)	84.4	(35.8)		0.161	0.60
Mental health					0.236		
T0	71.1	(25.9)	73.3	(21.8)		0.807	0.36
T8	73.3	(21.8)	78.4	(25.1)		0.807	0.29
T16	78.4	(18.4)	76.7	(26.6)		0.807	0.23

CV, coefficient of variation for intervention group.
[a] ANOVA test.

found an ES of 37.2 in the 6 min walk test (95% CI 11.8 to 62.7); and in measuring the strength of triceps and reverse crucifix exercises the ES were 2.5 (95% CI 0.39 to 4.61) and 1.07 (95% CI 0.15 to 1.98) respectively. In T12 and T16, the strength measurements of rowing exercise showed an ES of 2.5 (95% CI 0.34 to 4.66) and 2.27 (95% CI 0.28 to 4.25) respectively; the strength measured in squat exercise showed an ES of 3.53 (95% CI of 6.93 to 0.4) in T12 and 4.77 (95% 1.02 to 8.52) in T16. Regarding the strength measurement of abdominal exercise we found an ES of 8.23 (95% CI 0.81 to 15.65) in T12 and 13 (95% CI 4.65 to 21.35) in T16.

Discussion

Exercises are widely recommended for the treatment of patients with AS; however, there is no consensus in the literature regarding the most efficient type of exercises.[27,28] Studies using exercises as a treatment for many diseases fail to describe the number of sets and repetitions, the training progression and a demonstration of the exercises for the study exercise protocol to be reproducible. A review of exercise programs for AS found five studies with muscle strengthening exercises, and none of these studies described the exercise program adequately, therefore it is difficult to define the optimal dose and progression of exercises.[9] The present study shows an exercise protocol that can be easily reproduced because it describes the exercises, the number of sets and repetitions and the progression of training loads. This protocol was shown to be effective and safe.

The exercise protocol presented in this study is in accordance with the recommendations of the American College of Sports Medicine regarding the muscle strength training progression, the number of sets and repetitions, and the rest intervals between sets.[8] Because these recommendations are for healthy adults, we believe that our training was intense for sedentary patients with a chronic systemic inflammatory disease. In this study, we also found that it was advantageous to establish the duration of the intervention at 16 weeks of strength training because we began to observe differences

Please cite this article in press as: Souza MC, et al. Swiss ball exercises improve muscle strength and walking performance in ankylosing spondylitis: a randomized controlled trial. Rev Bras Reumatol. 2016. http://dx.doi.org/10.1016/j.rbre.2016.09.009

between the groups in terms of strength improvement after 12 weeks. The study of Fernandez de Las Penas et al. was conducted for 16 weeks, and it compared conventional physiotherapy with global postural reeducation and demonstrated improvement in mobility and functional capacity in both groups.[11] Other studies using muscle-strengthening exercises as an intervention with shorter durations, such as 6, 8 and 12 weeks, showed conflicting results, although they had in common the lack of a detailed description of the load, the number of sets and the number of repetitions of the exercises, ensuring that it was difficult to compare the results.[12–14]

The decision to perform the exercises on a Swiss ball was made because of the benefits this type of exercise could offer to the patient during the execution of movements, such as the recruitment of the stabilizer muscles known as the "core". Exercises that activate the core muscles have been the subject of recent studies, and there is greater activation of these muscles in the exercises performed with the Swiss ball.[5,6] One study showed that strength and core stability were important in improving the performance activities of daily living in the elderly.[29] Pilates exercises that activate the core have been prescribed and are effective in the functional improvement of AS patients.[30] These findings justify our selection of exercises performed on the Swiss ball, although our goal was not to evaluate the effects of specific core exercises.

We believe that the improvement in performance of the 6-minute walk test has a direct relationship with improved muscle strength, particularly in the squat exercise during the last week of evaluation, which shows that the increase in strength in the lower limbs could determine the amount of improvement in the walking performance in patients with AS. These results corroborate the findings of previous studies regarding the correlation of muscle strength with aerobic capacity. In the study by Carter et al., which evaluated the physical abilities of patients with AS, the authors demonstrated that the reduction in aerobic capacity and exercise intolerance were largely explained by the weakness of the peripheral muscles, such as the quadriceps, observed in these patients.[3] The weakness of the lower limbs in patients has been documented in two studies by Sahin et al. that compared the strength and fatigue of the muscles of the ankle and knee of AS patients with healthy controls. The amount of fatigue was higher, and the muscle strength of the plantar flexors, ankle flexors and knee extensors was significantly lower in patients with AS.[26,31]

In this study, no differences were observed between the groups with respect to the functional capacity evaluation using the BASFI and HAQ-S. The BASFI and HAQ-S are validated instruments to measure functional capacity and use questions about daily living activities in patients with AS. Most questions are about simple activities such as dressing, getting up from a chair, and climbing steps. Thus, the instruments do not assess more intense physical activities and only detect changes in lighter physical tasks.[32] In our study, although the patients showed improvements of muscular strength they did not improve functional capacity. It is possible that the exercise program was more directed to increase physical fitness and did not achieve the objective of improving functional capacity.

In contrast, in the study by Lim et al., the exercises performed once a day for eight weeks improved the functional capacity of the intervention group compared to the control group.[26] A recent study by Gunay et al. that evaluated the effectiveness of breathing exercises and postures in a group of patients with AS demonstrated improvement in functional capacity, mobility, disease activity and quality of life in relation to the isolated group that performed postural exercises and the control group. A study by Gunay et al. used a small sample, and only intra-group comparisons were performed.[33] Few studies used the HAQ-S to assess the functional capacity of patients with AS who underwent an exercise program. A study by Sweeney at al found no differences in the HAQ-S between the patients who did home exercises versus group exercises for 9 months.[34]

The difference in functional capacity between groups might not have been impressive in our study because our patients were stable with drug treatment, and almost 40% of our patients were stable with the use of anti-TNF therapy. This might explain the lack of differences between the groups with respect to disease activity assessed by BASDAI and ASDAS-CRP/ESR and the use of analgesics and anti-inflammatory medications during the study period.

This study was the first to use the Timed up and go test timed up as a measuring tool to evaluate other parameters of functional capacity such as standing, walking and sitting in patients with AS. This test is widely used for the assessment of balance and mobility in the elderly.[35] Because both groups averaged less than 10 s from the initial assessment, both were considered freely mobile. It is possible that improvement in this test was not detected at the end of 16 weeks because the patients had shown good functional independence at baseline.

No differences were observed between the groups in terms of the quality of life assessed by the SF-36, although many studies show improvement in quality of life as a result of therapeutic exercises. It is possible that the instrument did not have sufficient sensitivity to changes to demonstrate the effects of the intervention in this population.

Although the effects on functional capacity, mobility and quality of life were modest, we believe that our exercise protocol has made a positive impact on patients because the patients' satisfaction regarding the treatment was high for the intervention group, with a statistical difference between the groups, showing that patients felt "better" or "much better" with treatment, as assessed by a Likert scale.

Adherence to the exercise therapy is one aspect that should be observed in studies with exercise programs because it is an important determinant of the beneficial response to intervention. In this study, adherence was high, with over 80% attendance at the training sessions. Most studies with physical exercise in AS do not describe patient compliance. A study comparing a physical therapy group with individualized home exercises reported adherence of 73.5% of the patients who participated in the supervised groups.[15] In this present study, the effect of group therapy, the continuous supervision by a physiotherapist and no worsening of inflammatory disease activity were identified as factors that led to the high adherence and patient satisfaction.

One limitation of this study was that the control group remained without intervention on a waiting list, which might have led to the intervention group benefitting by the contact

Please cite this article in press as: Souza MC, et al. Swiss ball exercises improve muscle strength and walking performance in ankylosing spondylitis: a randomized controlled trial. Rev Bras Reumatol. 2016. http://dx.doi.org/10.1016/j.rbre.2016.09.009

between the patient and the therapist. We believe that the treatment period could have been longer because changes in muscle strength were evident only after 12 weeks. Future studies of longer duration that compare different exercise protocols might show promising results.

In conclusion, the progressive muscle strengthening using the Swiss ball was effective in improving the muscle strength, walking performance and patient satisfaction in patients with AS. The exercise program has shown good tolerance without deleterious effects on the disease activity.

Funding

Clinicaltrials.gov: NCT01351311.

Grant # 2011/03459-9, São Paulo Research Foundation (FAPESP).

Conflicts of interest

The authors declare no conflicts of interest.

REFERENCES

1. Karapolat H, Akkoc Y, Sari I, Eyigor S, Akar S, Kirazli Y, et al. Comparison of group-based exercise versus home-based exercise in patients with ankylosing spondylitis: effects on Bath Ankylosing Spondylitis Indices, quality of life and depression. Clin Rheumatol. 2008;27:695–700.
2. Zochling J, Van Der Heijde D, Dougados M, Braun J. Current evidence for the management of ankylosing spondylitis: a systematic literature review for the ASAS/EULAR management recommendations in ankylosing spondylitis. Ann Rheum Dis. 2006;65:423–32.
3. Carter R, Riantawan P, Banham SW, Sturrock RD. An investigation of factors limiting aerobic capacity in patients with ankylosing spondylitis. Respir Med. 1999;93:700–8.
4. American College of Sports Medicine. American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. Med Sci Sports Exerc. 2009;41:687–8.
5. Sundstrup E, Jakobsen MD, Andersen CH, Jay K, Andersen LL. Swiss ball abdominal crunch with added elastic resistance is an effective alternative to training machines. Int J Sports Phys Ther. 2012;7:372–80.
6. Escamilla RF, Lewis C, Bell D, Bramblet G, Daffron J, Lambert S, et al. Core muscle activation during Swiss ball and traditional abdominal exercises. J Orthop Sports Phys Ther. 2010;40:265–76.
7. American College of Sports MedicineChodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR, et al. American College of Sports Medicine position stand. Exercise and physical activity for older adults. Med Sci Sports Exerc. 2009;41:1510–30.
8. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, et al., American College of Sports Medicine. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc. 2011;43:1334–59.
9. Dagfinrud H, Halvorsen S, Vøllestad NK, Niedermann K, Kvien TK, Hagen KB. Exercise programs in trials for patients with ankylosing spondylitis: do they really have the potential for effectiveness? Arthritis Care Res (Hoboken). 2011;63:597–603.
10. O'Dwyer T, O'Shea F, Wilson F. Exercise therapy for spondyloarthritis: a systematic review. Rheumatol Int. 2014;34:887–902.
11. Fernandez-de-Las-Penas C, Alonso-Blanco C, Morales-Cabezas M, Miangolarra-Page JC. Two exercise interventions for the management of patients with ankylosing spondylitis: a randomized controlled trial. Am J Phys Med Rehabil. 2005;84:407–19.
12. Analay Y, Ozcan E, Karan A, Diracoglu D, Aydin R. The effectiveness of intensive group exercise on patients with ankylosing spondylitis. Clin Rehabil. 2003;17:631–6.
13. Lim HJ, Moon YI, Lee MS. Effects of home-based daily exercise therapy on joint mobility, daily activity, pain, and depression in patients with ankylosing spondylitis. Rheumatol Int. 2005;25:225–9.
14. Cagliyan A, Kotevoglu N, Onal T, Tekkus B, Kuran B. Does group exercise program add anything more to patients with ankylosing spondylitis. J Back Musculoskelet Rehabil. 2007;20:79–85.
15. Hidding A, van der Linden S, Boers M, Gielen X, de Witte L, Kester A, et al. Is group physical therapy superior to individualized therapy in ankylosing spondylitis. A randomized controlled trial. Arthritis Care Res. 1993;6:117–25.
16. Van Der Linden S, Valkenburg HA, Cats A. Evaluation of diagnostic criteria for ankylosing spondylitis. A proposal for modification of the New York criteria. Arthritis Rheum. 1984;27:361–8.
17. Cusmanich KG, Kowalski SC, Gallinaro AL, Goldenstein-Schainberg C, Souza LA, Gonçalves CR. Cross-cultural adaptation and validation of the Brazilian–Portuguese version of the Bath Ankylosing Spondylitis Functional Index (BASFI). Rev Bras Reumatol. 2012;52:733–41.
18. Shinjo SK, Goncalves R, Kowalski S, Gonçalves CR. Brazilian–Portuguese version of the Health Assessment Questionnaire for Spondyloarthropathies (HAQ-S) in patients with ankylosing spondylitis: a translation, cross-cultural adaptation, and validation. Clin Rheumatol. 2007;26:1254–8.
19. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002;166:111–7.
20. Podsiadlo D, Richardson S. The timed up & go: a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991;39:142–8.
21. Shinjo SK, Goncalves R, Kowalski S, Gonçalves CR. Brazilian–Portuguese version and applicability questionnaire of the mobility index for ankylosing spondylitis. Clinics. 2007;62:139–44.
22. Sieper J, Rudwaleit M, Baraliakos X, Brandt J, Braun J, Burgos-Vargas R, et al. The Assessment of SpondyloArthritis international Society (ASAS) handbook: a guide to assess spondyloarthritis. Ann Rheum Dis. 2009;68 Suppl 2:ii1–44.
23. Ciconelli RM, Ferraz MB, Santos W, Meinao I, Quaresma MR. Brazilian–Portuguese version of the SF-36. A reliable and valid quality of life outcome measure. Rev Bras Reumatol. 1999;39:143–50.
24. Machado P, Landewé R, Lie E, Kvien TK, Braun J, Baker D, et al. Ankylosing Spondylitis Disease Activity Score (ASDAS): defining cut-off values for disease activity states and improvement scores. Ann Rheum Dis. 2011;70:47–53.
25. Drinkwater BL. A comparison of the direction-of-perception technique with the Likert method in the measurement of attitudes. J Soc Psychol. 1965;67:189–96.
26. Sahin N, Ozcan E, Baskent A, Karan A, Kasikcioglu E. Muscular kinetics and fatigue evaluation of knee using by

Please cite this article in press as: Souza MC, et al. Swiss ball exercises improve muscle strength and walking performance in ankylosing spondylitis: a randomized controlled trial. Rev Bras Reumatol. 2016. http://dx.doi.org/10.1016/j.rbre.2016.09.009

isokinetic dynamometer in patients with ankylosing spondylitis. Acta Reumatol Port. 2011;36:252–9.
27. Harper BE, Reveille JD. Spondyloarthritis: clinical suspicion, diagnosis, and sports. Curr Sports Med Rep. 2009;8:29–34.
28. Ozgocmen S, Akgul O, Altay Z, Altindag O, Baysal O, Calis M, et al., Anatolian Group for the Assessment in Rheumatic Diseases. Expert opinion and key recommendations for the physical therapy and rehabilitation of patients with ankylosing spondylitis. Int J Rheum Dis. 2012;15:229–38.
29. Granacher U, Gollhofer A, Hortobágyi T, Kressig RW, Muehlbauer T. The importance of trunk muscle strength for balance, functional performance, and fall prevention in seniors: a systematic review. Sports Med. 2013;43:627–41.
30. Altan L, Korkmaz N, Dizdar M, Yurtkuran M. Effect of Pilates training on people with ankylosing spondylitis. Rheumatol Int. 2012;32:2093–9.
31. Sahin N, Ozcan E, Baskent A, Karan A, Ekmeci O, Kasikcioglu E. Isokinetic evaluation of ankle muscle strength and fatigue in patients with ankylosing spondylitis. Eur J Phys Rehabil Med. 2011;47:399–405.
32. Jennings F, Oliveira HA, de Souza MC, Cruz VG, Natour J. Effects of aerobic training in patients with ankylosing spondylitis. J Rheumatol. 2015;42:2347–53.
33. Günay MO, Bal S, Bayram KB, Harman E, Dalgıç EE, Koçyiğit H, et al. The effect of breathing and posture exercise on the clinical, functional status and disease related quality of life in patients with ankylosing spondylitis. Med-Science. 2012;1:103–17.
34. Sweeney S, Taylor G, Calin A. The effect of a home based exercise intervention package on outcome in ankylosing spondylitis: a randomized controlled trial. J Rheumatol. 2002;29:763–6.
35. Steffen TM, Hacker TA, Mollinger L. Age- and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and gait speeds. Phys Ther. 2002;82:128–37.

Please cite this article in press as: Souza MC, et al. Swiss ball exercises improve muscle strength and walking performance in ankylosing spondylitis: a randomized controlled trial. Rev Bras Reumatol. 2016. http://dx.doi.org/10.1016/j.rbre.2016.09.009