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Stretch breaks in the work setting improve flexibility and grip strength and reduce musculoskeletal complaints

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Abstract—This study investigated the effect of a stretch break program (SBP) on the flexibility, strength and musculoskeletal complaints of storage (SW) and administrative (AW) sector workers. Twenty-six male workers were randomly selected: 16 workers from the storage sector and ten workers from the administrative sector. We applied the Physical Activity Questionnaire and Musculoskeletal Questionnaire and evaluated flexibility and grip strength before and after 6 months of the SBP. The SPB decreased the SW group members' complaints of paresthesias and numbness in the upper body and total body. The SPB reduced the AW group members' complaints of paresthesias and numbness in the upper body. Furthermore, the SPB improved cervical, trunk and left shoulder flexibility in the SW group and improved cervical and shoulder flexibility and grip strength in the AW group. The SBP contribute to improve flexibility and musculoskeletal complaints in the regions that are affected by higher rates of work-related injuries.

Keywords: flexibility, musculoskeletal symptoms, strength, stretch break, workers

Resumo—“Programa de ginástica laboral melhora a flexibilidade e força de preensão e reduz queixas osteomusculares em trabalhadores.” O presente estudo investigou o efeito de um programa de ginástica laboral (PGL) na flexibilidade, força e sintomas osteomusculares nos trabalhadores dos setores almoxarifado (GTA) e administrativo (GTAD). Vinte e seis trabalhadores do sexo masculino foram selecionados aleatoriamente: dezesseis GTA e dez GTAD. Aplicamos os questionários de atividade física e de sintomas osteomusculares e avaliamos a flexibilidade e força de preensão manual antes e após seis meses da PGL. O PGL diminuiu o número de queixas de parestesias e dormência dos membros superiores e no corpo total no GTA. O PGL reduziu o número de queixas de parestesias e dormência dos membros superiores e no GTAD. Além disso, o PGL melhorou a flexibilidade da cervical, do tronco e do ombro esquerdo no grupo GTA e a flexibilidade da cervical e ombro e força de preensão no grupo GTAD. O PGL contribuiu para melhoria da flexibilidade e queixas osteomusculares nas regiões corporais com maiores índices de lesões provenientes do trabalho.

Palavras-chave: flexibilidade, força, ginástica laboral, trabalhadores, sintomas musculo-esqueléticos

Resumen—“Programa de gimnasia laboral mejora la flexibilidad y la fuerza de presión y reduce las quejas musculoesqueléticas en los trabajadores.” El presente estudio investigó el efecto de un programa de gimnasia laboral (PGL) en la flexibilidad, la fuerza y síntomas musculoesqueléticos en los sectores trabajadores de almacén (GTA) y administrativa (GTAD). Veintiséis trabajadores de sexo masculino fueron seleccionados aleatoriamente: dieciséis GTA y diez GTAD. Aplicamos los cuestionarios de la actividad física y los síntomas musculoesqueléticos y evaluamos la flexibilidad y fuerza de presión antes y después de 6 meses de PGL. El PGL disminuyó el número de quejas por parestesias y de entumecimiento de la parte superior del cuerpo y cuerpo total en el GTA. El PGL redujo el número de quejas por parestesias y entumecimiento de los miembros superiores en GTAD. Además, PGL mejoró la flexibilidad del cervical, el tronco y el hombro izquierdo en el grupo de GTA y flexibilidad del hombro, el cervical y la fuerza de presión en el grupo GTAD. El PGL contribuyó a mejorar la flexibilidad y musculoesqueléticos quejas en regiones del cuerpo con las mayores tasas de lesiones de trabajo.

Palabras claves: flexibilidad, la fuerza, la gimnasia laboral, los trabajadores, los síntomas musculoesqueléticos

Introduction

Cumulative trauma disorder is a collection of musculoskeletal disorders characterized by chronic discomfort, pain and possibly

functional impairment (Trujillo & Zeng, 2006). Repetitive movements are commonly performed and abnormal or prolonged postures or positions are commonly assumed during many work activities, such as administrative or storage duties,

and these motions can cause cumulative trauma disorder (Dick, Graveling, Munro, & Walker-Bone, 2011, Lowe & Dick, 2015). These activities lead to muscle imbalance, which results in a mechanical disadvantage and weakness. In addition, these activities may increase the pressure around a nerve, stretch the nerve, or decrease blood flow, thereby producing fibrosis in the nerve (Trujillo & Zeng, 2006; Varatharajan *et al.*, 2014).

In Europe, 25% of workers report work-related neck/shoulder pain, and 15% report work-related arm pain (Kraker & Blatter, 2005). Between 2002 and 2004 in the Netherlands, 28% of workers reported experiencing neck/shoulder or elbow/wrist/hand symptoms caused by work activities during the previous 12 months; moreover, 2 to 4% of all workers use their yearly sick leave for work-related neck and upper limb problems, which account for 4 to 6% of the total number of sick days and last for 3 to 4 years on average (Heinrich & Blatter, 2005). High work demands and minimal levels of control at work are often related to these types of symptoms (Bongers, Ijmker, van den Heuvel, & Blatter, 2006). In the Netherlands the yearly costs of work-related neck/upper limb symptoms were estimated at 2.1 billion euros, counting decreased productivity, chronic incapacity, sick leave, and medical expenses (Bernaards, Ariens, & Hildebrandt, 2006). However, in the last decade, the incidence of work-related disabilities caused by neck and upper limb symptoms has decreased to 2% (Van den Heuvel, Van der Beek, Blatter, & Bongers, 2006).

Workplace health promotion (WHP) programs may be important for alleviating discomfort, pain, tension, visual tiredness, fatigue and psychiatric disorders in workers. WHP programs include employee education, modified workspace designs, adjusting work habits and promoting exercise, stretches and short rest breaks. The physiologic benefits of a stretch break program include reduced intervertebral disc pressure, increased blood flow, reductions in muscle lactic acid and increased attention (Andersen *et al.*, 2012; Balci & Aghazadeh, 2003; Cheema *et al.*, 2013; Varatharajan *et al.*, 2014; Zebis *et al.*, 2011).

Previous studies have demonstrated the effects that additional breaks have on reducing musculoskeletal discomfort (Balci & Aghazadeh, 2004; McLean *et al.*, 2001). However, the studies by Karwowski *et al.* (Karwowski, Eberts, Salvendy, & Noland, 1994) and Henning *et al.* (Henning, Jacques, Kissel, Sullivan, & Alteras-Webb, 1997) did not reveal a positive effect of added breaks. A recent systematic review concluded that few high-quality studies have examined the effect of office ergonomic interventions on health; the interventions that focused on rest breaks (four studies) yielded mixed evidence supporting the positive impact of rest breaks on musculoskeletal health and moderate evidence (two studies) that rest breaks with stretching exercises had no impact on musculoskeletal health (Brewer *et al.*, 2006). More studies are needed to reach a more definitive conclusion about the effectiveness of added rest breaks.

In the current prospective cohort study, we investigated the effects of a stretch break program (SBP) on the flexibility, strength, and musculoskeletal symptoms of storage workers (SW) and administrative workers (AW).

Methods

Subjects

Twenty-six healthy male workers participated in this prospective cohort study. Information about the volunteers' health was obtained from the company's Occupational Health Medical Control Program (OHMCP); none of participants were taking daily medications or prescription medications. This study was conducted in strict accordance with the recommendations proposed by the Guide for the Care and Use of Humans and Ethics Committee of the University Cruzeiro do Sul by the São Paulo, Brazil approved the study (Permit Number: 026/2009).

Experimental design

We recruited forty-three male workers from two work sectors in a sports equipment distributor in São Paulo, Brazil. We excluded the participants who were fired during the study (15), a worker who did not join the program (1) and a worker who worked in more than one sector (1). We selected sixteen workers from the storage sector (SW; age: 28 ± 2.1 years, body mass: 77 ± 3.6 kg, height: 175 ± 2.1 cm and BMI: 24.8 ± 0.7 kg/m²), and 10 from the administrative sector (AW; age: 30 ± 2.9 years old, body mass: 79 ± 4.3 kg, height: 179 ± 1.9 cm and BMI: 24.7 ± 1.0 kg/m²). There were no changes in the demographic characteristics of the groups before and after the 6-month SBP. We also found no differences between the groups (Table 1).

Table 1. Demographic characteristics before and after the 6-month stretch break program.

	Before	After	Before	After
	SW		AW	
Volunteers	16		10	
Age (years)	28 ± 2	28 ± 2	30 ± 3	30 ± 3
Weight (Kg)	77 ± 4	77 ± 3	79 ± 4	79 ± 4
Height (cm)	175 ± 2	175 ± 2	179 ± 2	179 ± 2
BMI (kg/m²)	25 ± 1	25.0 ± 1	25 ± 1	25 ± 1

The values are expressed as the mean + SEM. SW = storage workers and AW = computer-using administrative workers.

All of the subjects participated in the SBP and performed occupational activities in one sector only. The occupational activities of both groups required distinct abilities and postures according to the information obtained from the participating company's Occupational Health Medical Control Program (OHMCP). The SW group accepts delivery items and storage of such items; prepares, alters and processes new or used sports equipment and garment and inventories for delivery to customers; maintains inventory levels and their records, receives new materials from vendors and notifies supervision of problems such as back orders or wrong items sent; prepare products according to route, customer and individual user, then place into route carts/bins for loading into delivery vehicles or designated area. The AW group work at a rate to keep up with the flow of products and delivery date

requirements and place garment orders using a computer, phone or fax, maintain inventory levels, perform withdrawals, inventories, maintain records and prepare reports or orders. The performed the SBP at the beginning of their workday in preparation for their work activities. For six consecutive months, the workers performed the SBP for 15 minutes at a time, three times per week for the SW groups and two times per week for the AW group. The subjects also received monthly educational information notices and satisfaction surveys and were monitored via daily attendance records and monthly sector reports.

Physical education teacher developed SBP monthly, safely and progressively over the six month intervention period and were primarily selected to correspond to the musculature the workers used during their workday. The physical education professional introduced and performed the exercises, corrected the participants and coordinated the educational information notices and satisfaction surveys. All of the exercises satisfied biomechanical criteria for safety and practical criteria to ensure minimal work disruption. The exercises were progressive according to fitness acquired by the workers increasing the number of sets, repetition and/or exercise time.

The SBP was group-based and prescribed into three step: warm-up (3 minutes), static and dynamic stretching exercises (10 minutes) and relaxation (2 minutes). In the first and third week of the month, we gave special attention to muscle groups of the shoulders, neck, trunk, hand, fingers, hip, thigh and knee in the SW and AW. In the second and fourth week of the month elbow, forearm, hip, thigh, ankle and foot muscle groups was prioritized to the SW groups and elbow, forearm, hand, fingers, hip, thigh, ankle and foot muscle groups to AW (Appendix 1). In each session, we applied approximately 10 exercises including 2 to 3 resistance exercises and 7 to 8 static or dynamic stretching. Static stretching was done through exercises with maintenance of posture during 20-30 seconds; dynamic stretching was carried by 1 or 2 workout series of 8 to 10 repetitions and resistance exercise by 2-3 sets of 10 repetitions (Figure 1).

We used Yellow / Red and Thin / Medium Theraband Resistance Bands™ in resistance exercise for AW and Red / Green and Medium / Heavy Theraband Resistance Bands™ for SW. We prioritized dynamic stretching with the recruitment of a larger number of joints and muscle groups in each exercise in the SW and static stretch with the selective and progressive recruitment of joints and muscle groups in the AW (Figure 2).



Figure 1. Representative exercises of SBP in AW and SW: ankle (A), hip and knee (B), hip, trunk and knee (C), knee (D), neck/cervical (E), wrist and forearm (F), fingers (G), wrist and hands (H), shoulder and neck (I), shoulder (J), shoulder and elbow (K) and trunk and shoulder (L).

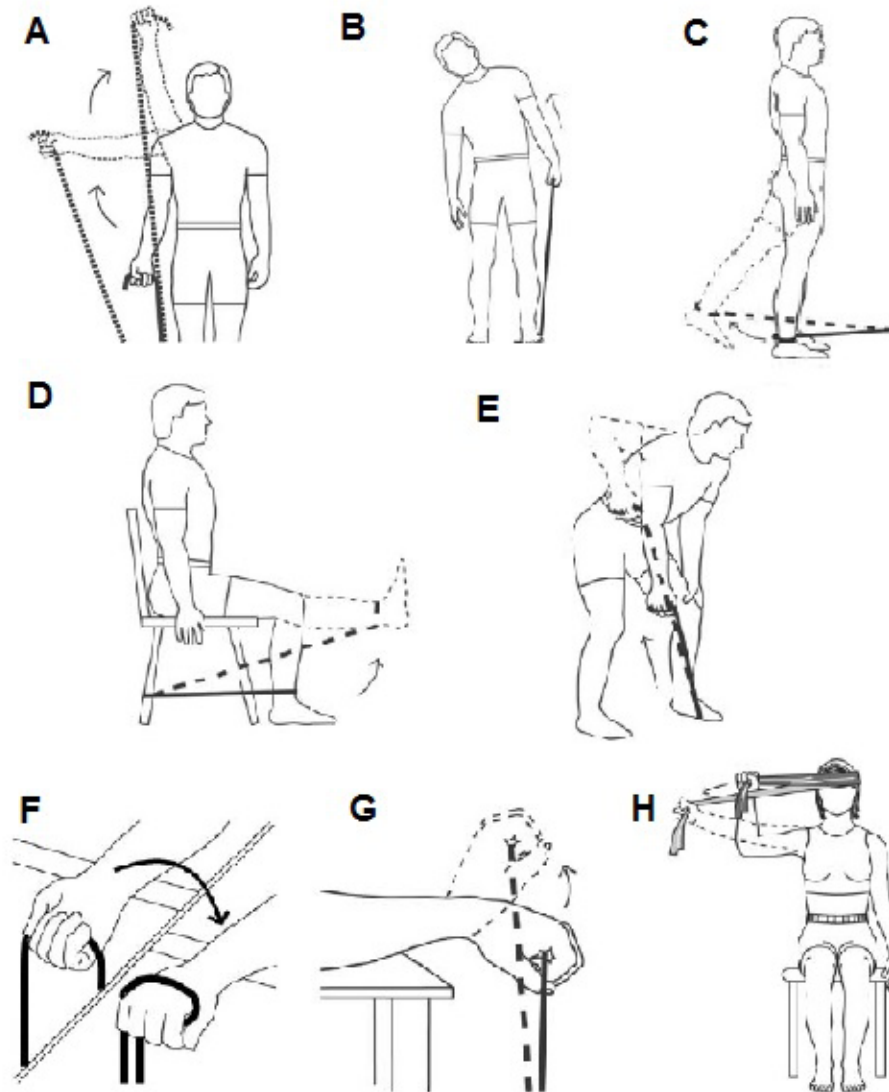


Figure 2. Representative exercises of SBP in AW and SW using resistance bands: shoulder (A), shoulder and trunk (B), hip (C), knee (D), elbow (E), wrist and forearm (F), fingers and wrist (G) and neck (H).

International Physical Activity Questionnaire (IPAQ)

We administered the International Physical Activity Questionnaire (IPAQ) short form in an interview by the researchers during the baseline health assessment. We used IPAQ to measure the participants' self-reported total physical activity, including work-related activities, transportation, domestic and leisure-time physical activities and walking as well as moderate- and vigorous-intensity physical activity over the previous 7 days (Wolin, Heil, Askew, Matthews, & Bennett, 2008). We calculated the Physical activity in terms of metabolic equivalent (MET)-minutes per week as follows: MET level x minutes of activity/day x days per week. The MET levels were defined as follows: walking = 3.3 METs,

moderate intensity = 4.0 METs and vigorous intensity = 8.0 METs (Wolin *et al.*, 2008).

Grip strength

We measured grip strength using a dynamometer (*JAMAR*[®], Canada), according to the method described by Peters *et al.* (Peters *et al.*, 2011). The Jamar dynamometer was placed in the participant's dominant side hand (DS) and non-dominant side (NDS) hand, and the examiner loosely held the readout dial to prevent the participant from dropping it. The volunteers performed three maximum voluntary contractions by each hand in alternating order. We used mean value for each hand for the

analysis. All of the participants were examined in a standardized position. Grip strength was expressed in kilograms (kg).

Flexibility measurements

Sit-and-reach test

We used a sit-and-reach test to assess flexibility. We used a Wells' bench (Personal Sanny, São Bernardo do Campo, Brazil), a box that measured 31 cm in height and 64 cm in length (with a top plate 41 cm in width). The first 23 cm of the top plate was extended over the front edge of the box towards the subject's feet. The adults sit with their knees straight and reach forward as far as possible from a seated position. The furthest position they reached with their fingertips determined the score. We performed three trials and recorded the highest score (Canadian Ministry of State, 1987).

Fleximeter

Leighton fleximeter (Code Research Institute, Brazil) composed of a small circular box with two 360° scales and a gravity-powered reading needle was used to measure axial and large-joint flexibility. The fleximeter was attached to Velcro and tied to the distal third of the articulation segment to be measured in parallel with the articulation, without compromising the width of the movement, while the reading needle was calibrated to zero. The subject executed the movement until he or she reached the maximum point that could be read. The axial and large joints included the cervical spine (lateral flexion), the shoulder (extension) and the trunk (lateral flexion) (Leighton, 1987). The device was reset after each of the three movements. The procedure was performed on the right and left sides, and the average registered values were used.

Nordic Musculoskeletal Questionnaire (NMQ)

A one-page questionnaire was included within the larger survey, and identical questions regarding the participants' pain and its consequences were asked independently for each of the three spinal regions. The questions relating to three regions of the spine were followed up for drawings that display the anatomical limits of the lumbar, thoracic and cervical. The participants were asked to reflect on their pain and its consequences for each spinal region separately. The questions were based on the standardized Nordic Musculoskeletal Questionnaire. The following variables were included: pain that has ever occurred, pain within the past year, the number of days with pain during the past year (categorized as "≤ 30 days" and "> 30 days") and pain radiating from the region of complaint (i.e., into the leg, chest or arm). The following independent variables were used to measure the consequences of back pain during the past year: "sought care," "reduced physical activity," "took sick leave," "changed work/work duties" and "sought/received disability

pension" (the latter two variables were analyzed in relation to the "pain that has ever occurred" variable) (Kuorinka *et al.*, 1987).

Statistical analysis

The data were entered into GraphPad Prism Version 5.0 (San Diego CA, EUA) and analyzed. The results were expressed as the mean ± standard error of mean (SEM) for 10 to 16 workers. The statistical analysis was performed using a paired t-test for comparing the quantitative data before and after 6 months of the SBP and for comparing the right and left sides (DS and NDS). To compare the number of participants with musculoskeletal symptoms before and after 6 months of the SBP we performed a paired test-t of the square root. A *p* value of < .05 was considered statistically significant.

Results

Physical activity levels

Based on the MET number/week, there were no observed differences after participation in the 6-month SBP in the amount of walking (from 587 ± 80 to 664 ± 124, *p* = .58), moderate activity (from 203 ± 95 to 293 ± 82, *p* = .41), vigorous activity (from 487 ± 210 to 747 ± 220, *p* = .29) and total activity (from 1278 ± 310 to 1706 ± 378, *p* = .28) performed by the SW, and there were no differences in the amount of walking (from 552 ± 113 to 472 ± 88, *p* = .56), moderate activity (from 328 ± 101 to 588 ± 213, *p* = .24), vigorous activity (from 160 ± 84 to 456 ± 282, *p* = .38) and total activity (from 1040 ± 231 to 1352 ± 395, *p* = .26) performed by the AW groups (Table 2).

Table 2. Metabolic equivalents per week before and after the 6-month stretch break program.

	Before	After	<i>p</i>	Before	After	<i>p</i>
	SW (MET/week)			AW (MET/week)		
Walking	587 ± 80	664 ± 124	.57	552 ± 113	472 ± 88	.56
Moderate Activity	203 ± 95	293 ± 82	.42	328 ± 101	588 ± 213	.24
Vigorous Activity	487 ± 210	747 ± 220	.29	160 ± 84	456 ± 282	.38
Total Activities	1278 ± 310	1706 ± 378	.29	1040 ± 231	1352 ± 395	.26

The values are expressed as the mean + SEM. SW = storage workers; AW = computer-using administrative workers; and MET = metabolic equivalent.

Musculoskeletal complaints

We observed that the SBP decreased the complaints of paresthesias and numbness during the last 7 days in the upper body (by 73%, from 11 to 3, *p* = .02) and total body (by 55%, from 20 to 9, *p* = .04) in the SW group (Table 3); for the AW group, participation in the SBP decreased complaints of paresthesias

and numbness over the last 12 months in the upper body (by 46%, 43 to 23 from $p = .02$) (Table 4). The lower limbs were not affected by the SBP in either group. Furthermore, implementing the SBP did not alter the number of workers who

were prevented from performing their regular activities (work, housework and leisure) or the number of workers who sought health professionals because of symptoms within the last 12 months (Tables 3 and 4).

Table 3. Number of musculoskeletal symptoms reported by the SW before and after the 6-month stretch break program.

Upper Limbs	Before SBP	After SBP	p
Musculoskeletal symptoms 12 m	19	15	.13
Prevented from performing activities	0	1	.33
Sought care from a health professional	4	0	.08
Musculoskeletal symptoms 7 d	11	3*	.02
Lower Limbs	Before SBP	After SBP	
Musculoskeletal symptoms 12 m	11	10	.90
Prevented from performing activities	4	2	.75
Sought care from a health professional	3	2	.83
Musculoskeletal symptoms 7 d	9	6	.33
Total	Before SBP	After SBP	
Musculoskeletal symptoms 12 m	30	25	.33
Prevented from performing activities	4	3	.93
Sought care from a health professional	7	2	.25
Musculoskeletal symptoms 7 d	20	9*	.04

The values are expressed as the mean + SEM. 12 m = the last 12 months and 7 d = the last seven days. * $p < .05$ for comparisons of the measurements at 0 and 6 months.

Table 4. Number of musculoskeletal symptoms reported by the AW before and after the 6-month stretch break program.

Upper Limbs	Before SBP	After SBP	p
Musculoskeletal symptoms 12 m	43	23*	.02
Prevented from performing activities	4	8	.18
Sought care from a health professional	5	10	.09
Musculoskeletal symptoms 7 d	5	3	.34
Lower Limbs	Before SBP	After SBP	
Musculoskeletal symptoms 12 m	7	7	.77
Prevented from performing activities	1	0	.34
Sought care from a health professional	1	2	.59
Musculoskeletal symptoms 7 d	1	0	.34
Total	Before SBP	After SBP	
Musculoskeletal symptoms 12 m	50	30	.10
Prevented from performing activities	5	6	.34
Sought care from a health professional	6	12	.35
Musculoskeletal symptoms 7 d	6	13	.34

The values are expressed as the mean + SEM. 12 m = the last 12 months and 7 d = the last seven days. * $p < .05$ for comparisons of the measurements at 0 and 6 months.

Flexibility

The six-month SBP did not improve the flexibility of the hamstring muscles, hips and lumbosacral regions, as evaluated by the sit-and-reach test, in either the SW (from 24.8 ± 2.9 cm to 26.1 ± 3.0 cm, $p = .017$) or the AW group (from 16.4 ± 2.9 cm to 15.9 ± 2.7 cm, $p = .65$; Table 5).

Cervical and shoulder flexibility did not differ between the right and left sides in the AW and SW groups before or after the SBP. There were also no differences in the trunk flexibility of the right and left sides of the AW group before or after

the SBP. However, in the SW group, the trunk flexibility was lower on the left side than the right side before the SBP ($p = .007$) but not after SBP (Table 5). After the 6-month SBP, we observed improvements in right and left cervical flexibility (by approximately 8%, $p = .02$), right and left trunk flexibility (by approximately 15 – 20%, $p = .0001$) and left shoulder flexibility (by 4%, $p = .03$) in the SW group and in the right and left cervical flexibility (by 15%, $p = .03$ and by 11%, $p = .04$, respectively) and the right and left shoulder flexibility (by approximately 10%, $p = .005$ and $p = .003$, respectively) in the AW group (Table 5).

Table 5. Flexibility before and after the 6-month stretch break program.

	Before		p	After		p
	SW			AW		
Volunteers	16			10		
SRT (cm)	25 ± 3	26 ± 3	.17	16.4 ± 3	15.9 ± 3	.65
R Cervical (degrees)	50 ± 3	55 ± 2*	.03	45 ± 3	51 ± 4*	.03
L Cervical (degrees)	48 ± 2	52 ± 2*	.02	44 ± 2	49 ± 2*	.05
R Shoulder (degrees)	152 ± 3	149 ± 3	.49	149 ± 4	166 ± 3*	.005
L Shoulder (degrees)	149 ± 3	156 ± 2*	.03	149 ± 3	165 ± 3*	.003
R Trunk (degrees)	43 ± 2	50 ± 2*	.01	41 ± 2	46 ± 1	.12
L Trunk (degrees)	40 ± 1#	49 ± 2*	.01	42 ± 2	45 ± 2	.12

The values are expressed as the mean + SEM. SW = storage workers and AW = computer-using administrative workers. SRT = Sit-and-Reach Test. R = right; L = left. * $p < .05$ for comparisons of measurements at 0 and 6 months. # $p < .05$ for comparisons between the R trunk and the L trunk.

Grip strength

Before implementing the SBP, the grip strength of the SW group was higher than the AW group on both the DS (from 39.9 ± 1.4 to 33.7 ± 1.8 kg, $p = .0163$) and the NDS (from 37.3 ± 1.1 to 29.8 ± 1.9 kg, $p = .0043$) (Table 6). The SBP did not alter the grip strength in the SW group and increased

the grip strength on the DS and the NDS in the AW group. In the AW group, grip strength was greater on the DS only before the SBP. In the SW group, grip strength was greater on the DS compared with the NDS both before and after the SBP (Table 6).

Table 6. Grip strength before and after the 6-month stretch break program.

	Before		p	After		p
	SW			AW		
Volunteers	16			10		
Dominant (Kg)	40 ± 1	40 ± 1	.65	34 ± 2	40 ± 3 *	.02
Non-dominant (Kg)	37 ± 1 #	37 ± 1 #	.81	30 ± 2 #	36 ± 2 *	.001
p	.01	.03		.001	.11	

The values are expressed as the mean + SEM. SW = storage workers and AW = computer-using administrative workers. Kg, kilograms. # $p < .05$ for comparisons between the dominant and non-dominant sides. * $p < .05$ for comparisons between 0 and 6 months.

Discussion

Our findings demonstrated that a 6-month strength break program reduced musculoskeletal discomfort in different body segments and improved the flexibility and grip strength of storage and administrative workers. Prior studies have shown that musculoskeletal symptoms may be immediately reduced by taking stretch breaks and by increasing the frequency of such breaks (Hagberg & Sundelin, 1986; Sundelin & Hagberg, 1989). Van Den Heuvel *et al.* (2003) observed a decrease in musculoskeletal symptoms and higher productivity among the workers in pause-and-stretch break intervention groups compared with a control group. Silverstein, Armstrong, Longmate & Woody (1988) reported that assembly line workers who participated in a stretch break program reported better recovery from discomfort despite the lack of significant reductions in symptoms upon assessment. Recently, a systematic review concluded that there are no evidences regarding the effectiveness of work disability prevention such as neck pain and upper extremity disorders. However, the researchers suggested that a return-to-work coordination program is more effective than clinic-based work hardening and that strength breaks

and workplace interventions benefits workers' recovery (Varatharajan *et al.*, 2014).

Previous studies have suggested that improving muscle strength and flexibility avoids CTD and musculoskeletal symptoms (Johnston *et al.*, 2014; Moreira-Silva, Santos, Abreu & Mota, 2014; Pedersen, Andersen, Zebis, Sjøgaard, & Andersen, 2013). The CTD reductions occurs during training phase with supervision and appears to be maintained a half year later, and can avoid symptoms on a low level but does not result in further pain reduction (Pedersen *et al.*, 2013). All of the participants in the AW group and most of the participants in the SW group exhibited below-average flexibility (from 30 to 33 cm) in their hamstring muscles, hips and lumbosacral regions. Improvements in lateral flexibility and muscle tension were observed among the metallurgical company workers, along with a decrease in the number of pain complaints and the number of painful segments, making a significant number of the participants asymptomatic. Fenety *et al.* (2002) and Feuerstein *et al.* (2004) demonstrated that implementing exercise programs led to significant reductions in musculoskeletal discomfort, postural immobility and functional limitations. The SBP increased flexibility in the cervical, trunk, and shoulder (left side) regions

in the SW group and the shoulder (right and left sides) and cervical regions in the AW group. The improved flexibility might have decreased the workers' complaints about paresthesias and numbness in their upper and total body regions.

However, the SBP did not alter the flexibility of the hamstring muscles, hips or lumbosacral regions in either group. The SBP was focused on the neck, shoulders, back, and upper extremities (hands and wrist) and not specifically on the hamstring muscles, hips or lumbosacral regions; this design may explain why the program had no effect on the flexibility of these regions. Lowe and Dick (2015) suggested that the effect of workplace exercise is minimal and effective as tertiary prevention and therapeutic relief of neck/shoulder symptoms. Moreover, previous studies have demonstrated that specific exercise programs improves strength and resistance levels of the trunk and lumbar extensors (Andersen *et al.*, 2012; Carvalho Mesquita, Ribeiro, & Moreira, 2012; Koumantakis, Watson, & Oldham, 2005), and these improvements appear after 6 to 8 months (Cohen, Goel, Frank, & Gibson, 1994). A 10-week yoga intervention delivered improves flexibility, state anxiety and musculoskeletal fitness in office positions workers (Cheema *et al.*, 2013). Supervised qigong, Iyengar yoga, or combined programs including strengthening, and flexibility appears also to be effective for the management of neck symptoms (Southerst *et al.*, 2014).

Postures or movements that engage antagonist muscle groups promote greater or lesser elongation, resulting in a mechanical disadvantage and weakness. In addition, certain positions increase the pressure or the extension of the nerves in the extremities, which results in chronic nerve compression, reducing blood flow, causing fibrosis, and impairing normal movement of the region or nerve (Higgs & Mackinnon, 1995). The occupational activities of the SW group involve manipulating storage boxes, relying more heavily on the right side of the shoulder and the trunk because all of the participants were right-hand. Thus, the SW group exhibited greater right trunk flexibility than left trunk flexibility before the SBP, and the SBP increased the trunk flexibility of both sides, creating balance between the two sides. However, the SBP only increased the flexibility of the non-dominant left shoulder. We suggest that right shoulder was more used to manipulating boxes than the right trunk because of the varying surface levels, hampering the effect of SBP.

Strength training relying on principles of progressive overload implemented in workers also reduces neck and shoulder pain (Zebis *et al.*, 2011). Sundstrup *et al.* (Sundstrup *et al.*, 2013, 2014) demonstrated that workplace initiatives reduce musculoskeletal pain among employees who perform repetitive and forceful work with their arms, shoulders and hands. Maintaining or increasing grip strength may be effective for preventing wrist injuries in computer users. Matias *et al.* (1998) reported that the incidence of wrist injuries is 8 to 38% and the probability of injury is 40% among computer workers. Rasotto *et al.* (2015) reported an improvement on upper limb pain and neck disability with concomitant increases in grip strength. The grip strength on the DS and the NDS was higher in the SW group compared with the AW group. Implementing the SBP increased the AW group's grip strength both on the DS and the NDS, but it had no effect on the SW group. In other studies, increasing

the frequency of pause breaks improved the workers' accuracy and/or speed during computer use (Balci & Aghazadeh, 2003; Kopardekar & Mital, 1994). Restrictions on workers' pause breaks during computer use have been identified as risk factors for musculoskeletal symptoms and injuries (Bergqvist, Wolgast, Nilsson, & Voss, 1995a, 1995b).

Our study presented the subjective evaluations of workers who participated in a 6-month SBP and the physiological effects of the program. Both the subjective evaluations and the physiological analyses revealed improvements in flexibility and a decrease in the number of reports of discomfort and other problems. Most of the studies on this subject have controlled for and investigated exercises using questionnaires and subjective evaluations that were compared to data regarding sick leave and/or medical treatments.

Conclusion

The reduction in musculoskeletal symptoms and the improvements in flexibility and grip strength during the 6-month intervention period demonstrate the importance of implementing and maintaining health promotion and physical activity programs in the work environment. We conclude that the SBP improved grip strength in the AW group and improved the flexibility of the body regions that are prone to work-related injuries in both groups. Ultimately, the SBP reduced the number of musculoskeletal complaints.

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Appendix 1. Monthly planning of SBP in AW and SW: joints, movements and mainly muscle groups.

First and Third Week		
Monday	Wednesday	Friday (#)
<p>Upper Limbs</p> <p>Shoulder flexion, extension, adduction and abduction Deltoid m. Biceps brachii m. Pectoralis major and minor m. Supraspinatus m. Trapezius m.</p> <p>Neck flexion, extension and rotation and lateral flexion Sternocleidomastoid m. long neck m. semispinalis capitis m. splenius capitis m.</p> <p>Trunk flexion, extension and rotation and lateral flexion rectos abdominis m. internal and external oblique m. semispinalis m. Rotators m. Iliocostal m.</p> <p>Hands and fingers abduction, adduction, flexion, extension flexor carpi radialis m. flexor digitorum profundus and superficialis m. extensor digitorum m. abductor pollicis longus m. adductor pollicis m.</p>	<p>Lower Limbs</p> <p>Hip flexion, extension, adduction, abduction and rotation adductors m. biceps femoris m. gluteus minimus, maximus and medius m. iliacus m. psoas m. rectos femoris m. sartorius m. vastus lateralis, intermedius and medialis m.</p> <p>Knee flexion, extension and rotation biceps femoris m. gastrocnemius m. gracilis m. rectos femoris m. sartorius m. vastus lateralis, intermedius and medialis m.</p>	<p>Upper and Lower Limbs</p> <p>Elbow flexion and extension biceps brachii m. brachialis m. Brachioradialis m. Triceps brachii m.</p> <p>Forearm, wrist flexion, extension, pronation and supination flexor carpi radialis m. pronator m. supinator m. extensor carpi radialis longus m.</p> <p>Ankle and Foot plantar flexion, dorsiflexion, inversion e eversion Fibularis m. Gastrocnemius m. Plantaris m. Anterior tibial m.</p>
Second and Fourth Week		
Monday	Wednesday	Friday (#)
<p>Upper Limbs</p> <p>Elbow flexion and extension biceps brachii m. brachialis m. Brachioradialis m. Triceps brachii m.</p> <p>Forearm and wrist flexion, extension, pronation and supination flexor carpi radialis m. pronator m. supinator m. extensor carpi radialis longus m.</p> <p>Hands and fingers (##) abduction, adduction, flexion, extension flexor carpi radialis m. flexor digitorum profundus and superficialis m. extensor digitorum m. abductor pollicis longus m. adductor pollicis m.</p>	<p>Lower Limbs</p> <p>Hip flexion, extension, adduction, abduction and rotation adductors m. biceps femoris m. gluteus minimus, maximus e medius m. iliacus m. psoas m. rectos femoris m. sartorius m. vastus lateralis, intermedius and medialis m.</p> <p>Ankle and Foot plantar flexion, dorsiflexion, inversion and eversion Fibularis m. Gastrocnemius m. Plantaris m. Anterior tibial m.</p>	<p>Upper and Lower Limbs</p> <p>Trunk flexion, extension and rotation and lateral flexion rectos abdominais m. internal and external oblique m. semispinalis m. Rotators m. Iliocostal m.</p> <p>Hip flexion, extension, aduction, abduction and rotation adductors m. biceps femoris m. gluteus minimus, maximus e medius iliacus m. psoas m. rectos femoris m. sartorius m. vastus lateralis, intermedius and medialis m.</p>

Exclusive for SW; ## Exclusive for AW