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Resistance Training Improves Physical Fitness and Reduces Pain Perception in Workers with Upper Limb Work-Related Musculoskeletal Disorders: A Pilot Study

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Abstract: Work-related musculoskeletal disorders (WRMDs) are a cause of productivity loss and disability. Resistance training (RT) and stretching seems to relieve pain, reducing the relative workload via an improvement in range of motion. Sixteen women (age: 48.69 $\pm$ 5.88 years old, working career duration as a packager: 22.75 $\pm$ 2.18 years) were recruited to participate in a 14-week work-based RT and stretching program. Specific exercise training (SET) targeting all body areas affected by WRMDs was performed after week 6. Physical fitness was measured via the 2 min step test (2MST), the back scratch test and the handgrip test (HG). To evaluate the level of pain in the cervical spine, shoulder, elbow and wrist, the visual analogue scale (VAS) was used. Differences were verified with a *t*-test. The cervical spine ($p = 0.02$) and left wrist ($p = 0.04$) VAS decreased, whereas the HG for both right ($p = 0.01$) and left ($p = 0.01$) hands and the 2MST ($p = 0.01$) improved. Participants with WRMDs affecting the cervical spine reported a 3.72 higher VAS score for the neck at the beginning of the protocol ($p = 0.03$). The protocol improved the physical fitness of participants but showed a limited effect on WRMD pain. The mean adherence was 86.2%, which indicated that exercise performed in the workplace is well accepted and could be used for pain management.

Keywords: workplace; occupational disease; strength training; stretching; upper limb

1. Introduction

Work-related musculoskeletal disorders (WRMDs) are injuries and/or dysfunctions affecting the human musculoskeletal system, which has been demonstrated to have a causal relationship with physical exertion [1] and psychosocial factors at work [2]. In epidemiological research, WRMDs are distinguished from "occupational disorders" by their multifactorial etiology and by the admission of non-occupational risk factors [3]. From a socioeconomic perspective, WRMDs are a cause of productivity loss and disability, and they incur considerable costs to the healthcare system [4].

After the review of nine theories of causation of WRMDs, Karsh presented an integrated model that explains the interaction between psychological and physical exposures, and the role of moderators and confounders, such as the social/cultural context, the environment and individual factors [5]. Individual factors (e.g., physical capacity, fatigue tolerance, aging) act directly on the linking pathway between physical work demand

and physical strain (tissue load), along with psychological work demands and psychological strain (anxiety). Particularly, physical capacity, fatigue tolerance and aging affect the biomechanical properties of the tissue or the relative load and, consequently, the risk of incurring WRMDs. More in depth, the demands of physical work cause tissue load through three mechanisms: (1) single overexertion over the threshold of tissue tolerance; (2) cumulative effect of multiple stimuli under the threshold; (3) a combination of both [6–8]. Another potential fourth actor is muscle fatigue, which decreases the force output and is correlated to the WRMD condition. However, there is no consensus on the causative mechanism involved.

Ergonomics, job design, risk assessment and consistent risk factor modification are common interventions to counteract WRMDs [9]. However, these aspects act on both dimensions, the work organization and the environment confounders, and not on the individual factors. Multicomponent interventions (education, exercise, treatment) have a greater chance of success than a single intervention in terms of prevention and reduction in WRMD consequences [9]. However, exercise alone seems to be a cost-effective treatment modality for the reduction of symptomatology [10–13]. The lack of time is a common barrier to exercise [14], but workplace intervention reports higher levels of participation [15,16], showing that practicing exercise during the working schedule could be a feasible solution. Exercise can enhance individual factors of the Karsh model, obtaining a protective effect. Particularly, strength training seems to relieve pain by accelerating protein synthesis and degradation, leading to reconstruction of abnormal or painful muscle tissue [17] or by reducing the relative workload due to strength improvement [18]. Stretching exercises seem to help with WRMD prevention and management through an improvement in range of motion and their analgesic properties [19]. Additionally, it seems that gender is a specific risk factor for upper limb WRMDs, with a higher prevalence for female workers [20]. As a matter of fact, previous research focused on female gender alone and the association with upper limb and neck disorders in female workers [21]. Moreover, a systematic review of longitudinal studies pointed out gender as a risk factor for wrist and hand disorders with reasonable evidence [22].

The aim of this pilot study was to evaluate the effect of structured resistance and stretching exercises on physical fitness and pain in the upper limb, and evaluate the difference in pain and performance of the cervical spine and upper limbs after a specific training program by comparing workers with and without WRMDs, and injured vs. non-injured arms. The hypothesis of this pilot study is that supervised resistance training can reduce pain in the affected body area, and improve physical fitness of the upper limbs. We expected greater improvements in participants with WRMDs due to specific exercise training.

2. Materials and Methods

2.1. Study Design

The present intervention was a one-group pretest–posttest pilot study performed between July and September 2017. This intervention study lasted for 14 weeks. In the first-week (T_0) medical examination, a health-related physical fitness, disability, symptom and physical activity assessment was performed. Exercise intervention was performed 2 times per week, and lasted 60 min; it took place from week 2 to week 13, and SET was started on week 6. A second assessment (T_1) was completed during week 14.

2.2. Participants

Sixteen women from a Italian food company company were recruited to participate in a work-based exercise program lasting 14 weeks. All participants were packagers. Inclusion criteria consisted of: (1) women with a working career duration $\geq$15 years with the company, (2) the practice of a repetitive job as evaluated by the occupational repetitive action index (OCRA) with a risk index higher than 3.6 (exposure level ranging from light to high), (3) diagnosis of disability and/or pain in an upper limb or the cervical spine due to WRMDs, (4) no actual practice of regular exercise, (5) commitment not to initiate other training programs and not to modify physical activity behavior during the period of the intervention. Subjects already involved in physical therapy for prevention and/or treatment of WRMDs were excluded. The recruitment strategy consisted of two steps: (1) information about the experiment was sent by e-mail to the employees of the company, asking for interest to take part in the study, (2) volunteers were examined for the presence of the inclusion criteria. Written informed consent was obtained prior to enrollment. The study complied with the Italian laws for research on human participants, and was approved by the local board of the University of Padova (ethical approval number: 2643P).

2.3. Medical History

The medical history taken by the occupational doctor and medical record of each participant was examined, searching for WRMDs. Moreover, a complete and detailed medical anamnesis was carried out prior to the intervention to confirm the actual presence of WRMDs, and to verify the absence of pathological conditions that could alter exercise response.

2.4. Exercise Program

The physical exercise protocol consisted of 24 sessions of a resistance and stretching exercise program, performed 2 times per week and lasting 60 min. Each session was supervised by an exercise specialist with a bachelor's degree in sport science. Resistance training (RT) exercises for the major muscle groups were performed by means of using an elastic band or free weight. Repetitions and sets ranged between 10–20 and 1–3, respectively. Isometric exercises lasted from 10 to 30 s based on the muscle mass involved. In order to standardize the intensity, Borg's category ratio scale 10 (CR10) was used to determine the level of exertion of the prime movers [22]. Participants were asked to exercise until muscle failure, confirmed by the CR10 score of 10/10. If the prescribed level of exertion was reached in the first set, the weight was maintained for the other sets; otherwise, the weight was adjusted and another attempt was made. Pain due to WRMDs was an absolute criterion to interrupt the set. To modify the intensity of RT exercises, variations in body position were administered to modify the lever arm. This approach implied an enormous variation in strength demand; consequentially, a repetition range was prescribed instead of a precise number. Through a combination of repetitions and sets, the volume was increased in a linear manner throughout the program. Exercises were organized in a circuit during the session without a passive rest interval, but alternated major muscle groups. A warm-up with exercises for general articular mobility preceded each session and static stretching exercises were performed at the end of the session for at least one set of 30 s for each muscle trained. Specific exercise training (SET) that targeted all body areas affected by WRMDs was performed during week 4 (Table 1). Adherence to the exercise program was recorded for each participant at each session. Exercise prescription was individualized; hence, all participants completed their personal exercise volume at the prescribed intensity.

2.5. Health-Related Physical Fitness Assessment

Physical fitness tests were chosen according to the classification proposed in ACSM's guidelines for exercise testing and prescription [23]. Tests were administered in a randomized order with 3 min of rest between trials to avoid fatigue. The cardiorespiratory endurance was evaluated via a 2 min step test (2MST). The final score was recorded as the number of steps executed correctly; moreover, perceived exertion was rated by each participant at the end of the test with the Borg scale CR10 [24]. The flexibility of muscles around the shoulder was evaluated using the back scratch test (BST). The right BST refers to the execution with the right hand raised. Since the handgrip strength test (HG) reflects overall body strength in untrained subjects [25], maximal isometric grip strength was used as a measure of muscular strength (Baseline, Elmsford, NY, USA). Only one trial of the 2MST was performed, whereas the mean between three trials was considered for the other tests. Baseline and post-intervention tests were conducted at the same time of the day. The performance of the tests was in accordance with the guidelines of Jones and Rikli [26].

Table 1. Resistance training program.

Week Number	Number of Sets	Repetitions	Intensity (CR10)	Number of Exercises	Number of Sets	Repetitions/ Duration (s)	Intensity (CR10)	Number of Exercises	Recovery Time (s)	Frequency (Sessions/ Week)
		RE				SET				
1						T_0 assessment				
2–3	1–3	8/20–10″/30″	10	10	n.a.	n.a.	n.a.	n.a.	40	2
4–7	2–3	8/20–10″/30″	10	6	3	8/20–10″/30″	10	4	30	2
8–10	2–3	8/20–10″/30″	10	6	3	8/20–10″/30″	10	4	30	2
11–13	2–3	8/20–10″/30″	10	6	3	8/20–10″/30″	10	4	30	2
14						T_1 assessment				

Category	Exercises	Muscle Involved
RE	Floor press	Chest
RE	Hands elevated push up	Chest
RE	Resistance band chest press	Chest
RE	Upright row	Shoulders/neck
RE	Band pull apart *	Shoulders/neck
RE	Lateral raise *	Shoulders/neck
RE	Front raise *	Shoulders/neck
RE	Face pull *	Shoulders/neck
RE	External/internal rotation *	Shoulders/neck
RE	Bicep curl	Biceps
RE	Push down	Triceps
RE	Crunches/plank	Abdominals
SPE	Isometric neck flexion/extension, lateral bending	Neck
SPE	Wrist flexion/extension (stretching/RE)	Wrist
SPE	Forearm supination/pronation (stretching/RE)	Forearm
SPE	Shoulder mobility exercises in all directions	Shoulders

At least one exercise for each major muscle group was performed through the weeks. In the repetitions/duration column, the double apostrophe (″) indicates seconds of maintenance of isometric exercise, except for neck isometric exercises that were performed for 5 s repetitions. Exercises marked with an asterisk (*) were RE and SET at the same time. Abbreviations: RE—resistance exercise/exercises; SET—specific exercise/exercises; CR10—category ratio 10; n.a.—not applicable.

2.6. Disability and Symptom Assessment

Before the intervention, the Italian version of the disabilities of the arm, shoulder and hand questionnaire (DASH) [27], and neck pain and disability scale (NPDS-I) [28] were administered to quantify the level of disability of the upper limb and neck. A NPDS-I score < 30 indicated a "low level of disability", a score between 30 and 70 an "intermediate level of disability" and a score higher than 70 a "high level of disability".

To evaluate the level of pain experienced in the cervical spine, shoulder, elbow and wrist, the visual analogue scale (VAS) was used [29]. A representation of the human body was shown to clearly indicate body parts to consider. The sum of the shoulder, elbow and wrist VAS scores constitute the upper body VAS score. All questionnaires were administered by interviewing participants.

2.7. Physical Activity Assessment

One researcher interviewed participants using the 16-item global physical activity questionnaire (GPAQ). According to the STEPS guidelines [30], participants who totaled 600 MET/week or more were considered as "active", participants between 1 and 599 MET/week as "less active" and those who totaled 0 MET/week as "sedentary".

2.8. Statistical Analysis

The Kruskal–Wallis test was conducted to examine the difference on disability and pain according to the physical activity level of participants. A dependent sample *t*-test was used to compare the pre–post means of all variables, considering the entire sample. To evaluate the assumption of normal distribution of the differences, the skewness and kurtosis modulus need to be lower than |2.0| and |9.0|, respectively [31]. If the assumption was not met, a Wilcoxon signed-rank test was ran. The Pitman–Morgan test was used to evaluate the homogeneity of correlated variance [32,33]. Participants were stratified in respect to the presence or absence of WRMDs in the upper limb or cervical spine. To evaluate the differences in pain and performance between participants with and without WRMDs, an independent *t*-test was used. Equality of variance was checked by means of Levene's test, and eventually, a correction for unequal variances was used. Moreover, an independent *t*-test was adopted to check the differences between the injured upper arm and the non-injured one in participants that reported upper limb WRMDs. The presence of outliers was not addressed due to the small sample size. The significance limit was set at $\alpha = 0.05$.

Pearson's correlation coefficient (ρ) was calculated between pre- and post-intervention evaluations. The correlation coefficient ranged from −1 to +1. A value of $p < 0.05$ was considered statistically significant.

The effect size was calculated only for significant changes according to Cohen's *d* formula, using the SD of the pre–post differences for repeated measures [34]. The standardized individual differences were computed as follows: the difference between the pre–post/SD of the differences [35]. We applied a cut-off value for a reliable change of 1.96 (two-tailed test). The percentage of reliable improvement (Pnet) for each group was computed and reported along with the ES and percentage of the change (%diff) for each significant repeated-measure test. Statistical analysis was performed with SPSS Statistics for Windows (SPSS Statistics for Windows, Version 25.0., Armonk, NY, USA: IBM Corp.).

3. Results

3.1. Anthropometric Characteristics

Sixteen women were recruited for the experiment, and three of them dropped out. The mean adherence to the exercise protocol was 86.2%. The global physical activity questionnaire analysis classified four participants as active, five as less active and four as sedentary. The mean DASH score was 29.36; according to NPDS-I, none of the participants reported a high level of neck disability, whereas eight participants reported an intermediate level and five a low level of neck disability. Musculoskeletal diseases of the upper limb were shown in nine participants, and in the cervical spine in four (Table 2).

3.2. Physical Activity Effect

The Kruskal–Wallis test was conducted to examine the difference between disability and pain according to the physical activity level of participants. No significant differences were found among the three groups for DASH (H = 0.67, $p = 0.72$), NPDS-I (H = 1.59, $p = 0.45$) and upper limb VAS (H = 0.78, $p = 0.68$).

Descriptive statistics are expressed as the median (IQR); active participants have DASH, NPDS-I and total VAS scores of 31.25 (16.57–49.38), 50 (16.75–56.25) and 16.5 (13.00–26.75), respectively; less active have scores of 27.50 (27.5–28.94), 37.00 (7.00–47.00) and 24.00 (9.50–32.00); and sedentary have scores of 33.72 (17.07–45.42), 30.5 (23.50–36.75) and 18.5 (9.50–24.50).

3.3. Pain and Physical Fitness

After the exercise intervention, the VAS score showed a trend toward a reduction in all body areas; however, only cervical spine pain (−1.85, $p = 0.02$, %diff = 47.06%, ES = 0.74, Pnet = 15.38%) and left wrist pain (−1.15, $p = 0.04$, %diff = 46.87%, ES = 0.61, Pnet = 7.69%) decreased significantly. Muscular strength evaluated with HG increased significantly for both the right (+3.71 kg, $p = 0.01$, %diff = 14.08%, ES = 1.25, Pnet = 23.08%) and left (+2.09 kg, $p = 0.01$, %diff = 8.04%, ES = 0.95) hands; on the contrary, for upper limb flexibility no significant difference was found. The left HG Pnet was not calculated as no participants exceeded the 1.96 SID threshold. Cardiorespiratory endurance improved significantly

(+8.08 steps, $p = 0.01$, %diff = 9.7%, ES = 0.85, Pnet = 61.54%) after exercise intervention, without significant change in the CR10 (Table 3).

Table 2. Anthropometric and clinical characteristics of the study participants.

Variables	All Participants—13	
	Mean (SD)	**Range (max–min)**
Anthropometric characteristics		
Sex (% F)	100	
Age (years)	48.69 (5.88)	38–60
Weight (Kg)	62.82 (4.58)	52–73
Height (cm)	166 (5)	155–179
BMI (Kg·m^{-2})	22.75 (2.17)	20–28
Working career duration (years)	22.75 (2.18)	19.68–27.89
Physical activity		
Vigorous PA (min/week)	79.62 (197.43)	0–720
Vigorous PA (MET/week)	636.92 (1579.41)	0–5760
Moderate PA (min/week)	332.31 (272.62)	0–900
Moderate PA (MET/week)	1329.23 (1090.46)	0–3600
Total PA (min/week)	411.92 (300.62)	0–780
Total PA (MET/week)	1966.15 (1717.12)	0–6000
Sedentary behavior (min/day)	239.23 (106.62)	60–480
Disability evaluation		
DASH scores	29.36 (12.76)	12.50–45.83
NPDS-I scores	Low level of disability: 5 participants Intermediate level of disability: 8 participants High level of disability: 0 participants	
Medical history	**Name**	
Upper limb (shoulder, wrist, elbow)	Trigger finger (1), carpal tunnel syndrome (3), lateral epicondylitis (2), supraspinatus tendinopathy (3)	
Cervical spine	Cervical bulging disk (4)	

Results are expressed as mean (SD). Abbreviations: BMI—body mass index; MET—metabolic equivalent of task; PA—physical activity; DASH—disabilities of the arm, shoulder and hand questionnaire; NPDS-I—neck pain and disability scale.

Table 3. Exercise intervention effects, descriptive statistics and comparisons.

Variables	Pre- to Post-Intervention Differences	r	r Sign.	95% CI of the Differences	t	Sign.
Upper limb VAS	–4.69 (9.18)	0.48	0.1	–0.85; 10.23	1.84	0.09
Cervical spine VAS	–1.85 (−0.76)	0.56	0.04	0.33; 3.36	2.65	0.02*
Right shoulder VAS	–0.46 (−1.39)	0.59	0.03	–0.95; 1.87	0.71	0.49
Left shoulder VAS	–1.38 (−0.62)	0.65	0.02	-8.41×10^{-4}; 2.77	2.18	0.05
Right elbow VAS	–0.08 (0.49)	0.07	0.81	–1.37; 1.53	0.12	0.91
Left elbow VAS	–0.69 (1.81)	0.74	0.00	–1.89; 0.5	–1.26	0.23
Right wrist VAS	–0.46 (−0.38)	0.89	0.00	–0.41; 1.38	1.15	0.27
Left wrist VAS	–1.15 (−1.44)	0.72	0.00		2.07 #	0.04 #*
Right BS (cm)	1.45 (4.74)	0.87	0.00		–0.22 #	0.82 #§
Left BS (cm)	–1.00 (5.16)	0.78	0.00	–2.12; 4.12	0.70	0.5
Right HG (kg)	3.71 (2.97)	0.91	0.00	–5.5; –1.92	–4.51	0.01 *
Left HG (kg)	2.09 (2.20)	0.93	0.00	–3.42; –0.77	–3.43	0.01 *
2MST (steps)	8.08 (9.50)	0.62	0.02	–13.82; –2.34	–3.07	0.01 *
CR10	0.15 (1.34)	0.74	0.00	–0.97; 0.66	–0.41	0.69

Data expressed as mean (standard deviation). *: $p < 0.05$; #: Wilcoxon test if equality of variance is not met (significant Pitman–Morgan test); §: Wilcoxon test if differences are not normally distributed. Abbreviations: r—Pearson correlation value; Sign.—significance (two-tailed); CI—confidence interval; VAS—visual analogue scale; BS—back scratch; HG—handgrip strength test; 2MST—2 min step test; CR10—category ratio scale 10.

3.4. SET Results

An independent *t*-test was used to test the hypothesis that the baseline pain and performance, and the mean difference between pain and performance of specific body areas (induced by exercise) were equal between participants who suffer from WRMDs and those who do not. The only significant difference was found in the baseline evaluation of the cervical spine VAS, with a mean VAS score of participants with WRMDs of 3.72 (p = 0.03, %diff = 50%, ES = 1.43, Pnet = 7.69%), which is higher than participants without diseases (Table 4).

Table 4. Comparisons between participants with and without WRMDs.

Upper Limb	No WRMDs (n = 4)	WRMDs (n = 9)	Levene's Test		Independent *t*-Test			
			F	Sign.	t	Sign.	Mean Diff.	95% CI
Δ Upper limb VAS	−0.75 (4.79)	−1.56 (3.97)	0.20	0.66	0.32	0.76	0.81	−4.76; 6.37
Δ HG	1.79 (2.82)	4.38 (3.13)	0.06	0.82	−1.41	0.19	−2.59	−6.62; 1.44
Δ 2MST	9.50 (11.27)	7.44 (9.29)	0.08	0.79	0.35	0.74	2.06	−11.00; 15.00
Δ CR10	0.50 (0.58)	0.00 (1.58)	1.28	0.28	0.60	0.56	0.50	−1.33; 2.33
Upper limb VAS T0	6.25 (3.95)	9.11 (3.37)	0.71	0.42	−1.35	0.21	−2.86	−7.54; 1.82
HG T0	28.33 (6.37)	23.78 (6.71)	0.02	0.88	1.14	0.28	4.56	−4.2; 13.31
2MST T0	89.50 (12.48)	80.56 (10.99)	0.00	0.98	1.30	0.22	8.94	−6.15; 24.04
Cervical Spine	**No WRMDs (n = 9)**	**WRMDs (n = 4)**	**Levene's Test**		**Independent *t*-Test**			
			F	**Sign.**	**t**	**Sign.**	**Mean Diff.**	**95% CI**
Δ Cervical Spine VAS	−1.22 (1.99)	−3.25 (3.30)	0.77	0.40	1.40	0.19	2.03	−1.17; 5.23
Δ HG	3.04 (3.40)	4.79 (2.55)	0.33	0.58	−0.91	0.38	−1.75	−5.97; 2.48
Δ 2MST	7.78 (9.46)	8.75 (11.03)	0.08	0.78	−0.16	0.87	−0.97	−14.08; 12.14
Δ CR10	0.33 (1.50)	−0.25 (0.96)	0.28	0.60	0.71	0.49	0.58	−1.23; 2.40
Cervical Spine VAS T0	2.78 (2.39)	6.50 (2.52)	0.09	0.77	−2.56	0.03 *	−3.72	−6.93; −0.52
HG T0	24.44 (6.96)	26.83 (6.75)	0.06	0.81	−0.58	0.58	−2.39	−11.52; 6.74
2MST T0	82.56 (13.38)	85.00 (8.29)	0.79	0.39	−0.33	0.75	−2.44	−18.58; 13.7

Data expressed as mean (standard deviation); *: $p < 0.05$. Abbreviations: Sign.—significance (two-tailed); WRMDs—work-related musculoskeletal diseases; Δ—difference from pre- to post-intervention; T0—baseline evaluation; CI—confidence interval; VAS—visual analogue scale; HG—handgrip strength test; 2MST—2 min step test; CR10—category ratio scale 10.

Another analysis between the injured and non-injured arm pain and performance of participants who suffer from upper limb WRMDs was performed. The baseline evaluation, such as the difference between pre- and post-intervention, recorded no significant difference between the two arms (Table 5).

Table 5. Comparisons between injured and non-injured arm.

Differences between Variables	Injured Arm	Non-Injured Arm	Differences	r	r Sign.	95% CI of the Differences	t(df)	Sign.
Δ Upper limb VAS	−1.11 (3.52)	−1.22 (3.8)	−0.11 (2.42)	0.78	0.01 *	−1.97; 1.75	−0.14	0.89
Δ HG	0.59 (8.25)	−1.03 (6.23)		0.91	0.01 *		−0.297	0.77 §
Upper limb VAS T0	9 (3.67)	7.11 (4.62)		0.71	0.03 *		−1.362	0.17 §
HG T0	25.59 (6.2)	27.49 (6.9)	−1.90 (5.22)	0.69	0.04 *	−5.91; 2.12	−1.9	0.31

Data expressed as mean (standard deviation); *: $p < 0.05$; §: Wilcoxon if differences are not normally distributed. Abbreviations: Δ—difference from pre- to post-intervention; T0—baseline evaluation; r—Pearson correlation value, Sign.—significance (two-tailed); CI—confidence interval; df—degrees of freedom; VAS—visual analogue scale; HG—handgrip strength test.

4. Discussion

The aim of this pilot study was to evaluate the effect of a resistance and stretching exercise program on physical fitness and pain in a group of female workers with neck and upper limb WRMDs. The baseline evaluation of participants included pain and disability of the upper limb and cervical spine. The influence of physical activity (PA) on pain level was investigated, considering that a previous study reported a relationship between a higher level of PA and less self-reported musculoskeletal disorders [36] and pain [37]. Upper limb VAS, DASH and NPDS-I did not differ in relation to the level of PA measured with the GPAQ, assuming that PA does not protect against pain and disability of the upper limb and neck in women with WRMDs. The working activity accounted for 62.26 (35.52)% on average in the calculation; thus, we assume that exposure to risk factors for WRMDs may have frustrated the benefits of PA. However, only four participants achieved the weekly recommended PA for healthy adults [38], and nobody performed adapted exercises for pain reduction.

The cervical spine and left wrist showed a VAS score reduction after the exercise program. These results, in light of a trend toward a reduction in pain in all body areas, seem to depict exercise as an effective tool to reduce symptomatology. Participants also improved their physical fitness: in fact, a significant increase in right and left grip strength and in cardiorespiratory endurance at the same mean effort was shown. Our results confirm previous findings that reported a reduction in neck pain and an improvement in HG after a work-based exercise program [10].

The back scratch test, assumed as a measure of flexibility of the muscle around the shoulder, did not differ after the treatment. Rasotto et al. reported a significant improvement in this test after a work-based exercise protocol [10]; however, the inclusion criteria did not look for WRMDs. Moreover, participants included in the referenced study reported a low mean level of right and left shoulder pain at baseline compared to our participants. For these reasons, we hypothesize that pain during the execution of the test or during the training probably played a part in determining the results. More investigations are needed to analyze in depth this phenomenon.

Participants were stratified according to the presence of WRMDs with a dual purpose: from one side, to evaluate whether the presence of WRMDs affects the baseline levels of pain and performance or the rate of improvement during the training period; from the other side, to evaluate if SET performed by injured participants could lead to large improvements in the main outcomes. Only participants who reported WRMDs in a specific body area undertook SET for that body area. Our hypothesis was that the presence of WRMDs implied a low level of performance and a higher level of pain at baseline with respect to the specific injured body area. Moreover, it was expected that the improvement in performance and the reduction in pain in the body area with WRMDs were higher due to the SET.

The results of the analysis showed that participants who reported WRMDs in the cervical spine experienced more symptoms than those who did not at baseline; contrarily, the upper limb VAS did not differ between the two groups at the baseline. Moreover, it was shown that the presence of WRMDs did not influence performance parameters at baseline, nor the change between baseline and post-training of all the variables considered. According to these findings, our hypothesis was not confirmed and SET seemed to not boost the improvement in the cervical spine or in the upper limb in people affected by WRMSDs. However, it could be possible that clustering individuals with shoulder, elbow and wrist pathologies into one unique category of "upper limb" hid differences in pain.

In the sub-group of participants with upper limb WRMDs, a further analysis was conducted to compare the injured arm with the non-injured arm at the baseline value and the mean change. As SET exercises were performed with both arms, the aim of this analysis was to understand if pain related to WRMDs or the presence of WRMSDs itself could change the exercise response. No differences were found, showing that the mean baseline pain level and strength did not differ between participants. Curiously, performing SET permitted the same reduction in pain and improvement in HG strength in both arms.

However, it is possible that a low exercise volume could have influenced the results; in fact, pain at baseline seems not to affect training volume [11] and a higher volume of RT is associated with better results in terms of pain reduction and physical fitness enhancement [39]. As the absolute volume that participants performed was low, it should be pointed out that a higher dose could have elicited a better response.

Limitations

This study has several limitations. Firstly, the one group pre- to post-test design prevents causal attribution; however, this work was a pilot study and a more in-depth investigation will follow. Future research could take into account other types of treatment for WRMDs in female workers to better understand the efficacy of resistance training for pain management in women with WRMDs. Secondly, the sample size was small and larger investigations are needed. Nevertheless, due to logistic limitations and delimited inclusion criteria, the recruitment of a large sample was difficult. In fact, the small sample size affected the ES calculation and the analysis of the secondary objectives of the study. However, it is feasible to use Student's *t*-test with an extremely small sample size (N < 5) [40].

5. Conclusions

The results showed a significant improvement in physical performance, with an increase in muscular strength and cardiorespiratory resistance. A supervised exercise program with the inclusion of SET partially improves pain perception evaluated with the VAS. These results suggested that the general variable of exercise training could be more important than specificity with respect to WRMDs. However, the introduction of SET could be an effective strategy to reduce the perception of effort during the session, maximize the attendance and reach the same benefits as a session with compound movements for major muscle groups. The mean adherence to the exercise protocol was 86.2%, which indicated that exercise performed in the workplace is well accepted by the employees and could be used for specific pain management.

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