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The effect of myofascial and physical therapy on trunk, shoulder, and elbow movement patterns in women with pain and myofascial dysfunctions after breast cancer surgery: secondary analyses of a randomized controlled trial

Myofascial therapy in breast cancer patients

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ABSTRACT

Introduction: Secondary upper limb dysfunctions are common after breast cancer treatment. Myofascial treatment may be a valuable physical therapy modality for this problem.

Objective: To investigate the effect of myofascial therapy in addition to physical therapy on shoulder, trunk, and elbow movement patterns in women with pain and myofascial dysfunctions at the upper limb after breast cancer surgery.

Design: A double-blinded randomized controlled trial

Setting: Rehabilitation unit of a university hospital.

Participants: Forty-eight women with persistent pain after finishing breast cancer treatment.

Interventions: Over three months, all participants received a standard physical therapy program. The experimental (n=24) and control group (n=24) received 12 additional sessions of myofascial therapy or placebo therapy, respectively.

Main outcome measures: Outcomes of interest were movement patterns of the humerothoracic joint, scapulothoracic joint, trunk and elbow, measured with an optoelectronic measurement system during the performance of a forward flexion and scaption task. Statistical parametric mapping (SPM) analyses were used for assessing the effect of treatment on movement patterns between both groups (group x time interaction effect).

Results: A significantly decreased protraction and anterior tilting was found post-experimental treatment. No beneficial effects on movement patterns of the humerothoracic joint, trunk and elbow were found.

Conclusion: Myofascial therapy in addition to a 12-week standard physical therapy program can decrease scapular protraction and anterior tilting (scapulothoracic joint) during arm movements. Given the exploratory nature of these secondary analyses, clinical relevance of these results needs to be investigated further.

Keywords: breast neoplasms, upper limb function, kinematics

INTRODUCTION

Breast cancer is the most frequently diagnosed cancer among women in the world [1]. Among the wide variety of breast cancer therapies, surgery and radiotherapy are usually the first treatment options. These therapies are known to cause secondary upper limb dysfunctions [2-4]. Breast and axillary surgery as well as radiotherapy have a direct and profound effect on soft-tissue structures at the upper limb region, including skin, muscles, and fascia [5-7]. Soft-tissue restrictions may directly cause movement pattern alterations at the level of the shoulder joint [8,9].

Reduction of the active range of motion is one of the most common morbidities at the upper limb region after finishing breast cancer treatment, with reported prevalence rates up to 84% [2,10-12]. Kinematic studies in women after breast cancer treatment show alterations in humerothoracic movement patterns, including a reduced elevation and external rotation [13-16]. The scapulothoracic joint may demonstrate increased internal rotation and total joint excursion [13,16,17]. Scapulothoracic lateral rotation may also be seen, though results are inconsistent seen. While an increased lateral rotation is reported in women post-mastectomy by Crosbie et al. (2010) [17], Ribeiro et al (2019) found a reduction in lateral rotation in women post-surgery [13].

Due to the influence of altered movement patterns on upper limb function in women after breast cancer treatment [4], research into rehabilitation approaches targeting upper limb movement capacity seems warranted. It is of interest to determine if targeting the soft tissue restrictions with myofascial therapy can improve soft-tissue mobility and prevent the consequent development and maintenance of specific movement alterations and upper limb dysfunction [18,19]. A recent systematic review with meta-analysis described greater overall effects in support of the intervention with myofascial therapy for pain and functionality than other control groups/types of interventions[20]. For pain in particular, our own study results showed beneficial effects of myofascial therapy in addition to a standard physical therapy program at short term (i.e. after the 12-week intervention). No beneficial effects on other self-reported and clinical outcome measures, including shoulder range of motion, were found[7,21]. Besides these outcomes, we hypothesize that myofascial therapy affects movement patterns of the shoulder by reducing soft tissue restrictions that may hamper certain movement patterns and/or reducing pain that may lead to avoidance of certain movements.

To fully assess the effect of myofascial therapy on movement patterns of the shoulder in the breast cancer population, objective three-dimensional motion capture of the shoulder joint, i.e. the scapulothoracic and humerothoracic joint, is needed. Furthermore, adjustments in movement patterns at the level of the adjacent joints of the shoulder, i.e., trunk and elbow, might be of interest to evaluate as well. Insights into the whole movement pattern (kinematic waveform) instead of gathering information on isolated joint angles at specific points in the movement (e.g. peak joint angle) may lead to a better understanding of this problem. To our knowledge, no previous studies have used this integrative approach to movement assessment in the breast cancer population.

The aim of this project was to explore the effect of myofascial therapy on the three-dimensional movement patterns of the humerothoracic joint, scapulothoracic joint, trunk, and the elbow during the performance of active elevation tasks. More specifically, a combination of decreased scapulothoracic protraction, lateral rotation, anterior tilting, increased humerothoracic elevation and external rotation, decreased trunk movement in all dimensions, and reduced elbow extension and/or supination are hypothesized. Objective opto-electronic motion analysis and kinematic waveform analyses were used for this purpose. The present study is a secondary analysis of a randomized controlled trial reported elsewhere [7,21].

METHODS

This study was approved by the Ethical Committee of the University Hospitals Leuven (ref number: MP01305). All participants gave written informed consent before data collection began. The trial has been registered at Nederlands Trial Register (NTR3610). The present manuscript presents secondary analyses of a randomized controlled trial, following the CONSORT guidelines. Results on the primary outcome and other secondary outcome measures of this trial can be found elsewhere [7,21].

Participants

Participants were recruited in the Multidisciplinary Breast Centre and the Department of Physical Medicine and Rehabilitation of the University Hospitals in Leuven from March 2013 until February 2015. The inclusion criteria were: (1) women after surgery for a primary breast cancer; (2) whose surgery and/or radiation therapy was finished at least three months prior. These participants had to: (3) score at least 40 out of 100 on the visual analogue scale (VAS) during the past week with more than three months of pain in the upper body region; and, (4) have presence of myofascial dysfunction at the upper body region (yes/no). Myofascial tissue evaluations were performed by a physical therapist through palpation for myofascial trigger points and/or adhesions between myofascial tissues. Potential participants were excluded if: (1) they were not able to visit the hospital for the therapeutic sessions and measurements for the entire duration of the study; (2) had existing shoulder pathologies for which surgical treatment was indicated (defined by ultrasound investigation); or, (3) a concurrent episode of cancer or metastasis.

Procedure

The participants were randomized into two groups. The randomization was computer-generated and was performed by using permuted blocks (size=4). The experimental group received a standard physical therapy program and additional myofascial therapy. The control group received the same standard physical therapy program, but with additional placebo therapy instead of myofascial therapy. The distribution of the participants into the two groups was blinded for the therapists, assessors and participants themselves.

Interventions

A standard physical therapy program of twelve weeks was planned for all participants. The first eight weeks, two one-on-one sessions were given per week. During week nine to twelve only one one-on-one session per week was provided. The sessions lasted 30 minutes and consisted of different physical therapy modalities, including: (1) passive mobilizations of the shoulder to improve the active and passive range of motion; (2) stretching of pectoral muscles to improve muscle flexibility and active and passive shoulder range of motion; (3) scar tissue massage to improve flexibility of the scar(s); and, (4) exercise therapy to improve muscle flexibility, endurance, strength, posture, scapulothoracic movement patterns, and active shoulder range of motion.

Immediately after the standard physical therapy session, the *experimental group* received **myofascial therapy** including manual myofascial release techniques on: (1) active myofascial trigger points; and, (2) on myofascial adhesions in the pectoral, axillary, and cervical regions, diaphragm, and scars. In short, the pressure applied by the therapist's hands proceed from the superficial to the deep layers of the myofascial tissue. Where a resistance is felt, the barrier is softly maintained until a release is felt. This approach is repeated until a soft end-feel is reached in every direction and layer. Participants in the *control group* received a **placebo treatment** consisting of static bilateral hand placements. While the previous group received more firm and dynamic techniques, the control group received a technique where myofascial tissues were not moved and where minimal pressure was applied. One session of myofascial/placebo therapy lasted 30 minutes with a frequency of once per week for twelve weeks. All interventions were performed by physical therapists with a Master of Science in Rehabilitation Sciences. More details on the interventions can be found elsewhere [21].

Outcome measures

The outcome measures described in this manuscript are the three-dimensional movement patterns of the humerothoracic and scapulothoracic joint, trunk, and elbow at the affected side. The movement analysis was performed using 15 infrared cameras sampling at 100 Hz (Vicon, Oxford Metrics, UK) and filtered with spline-interpolation[22] during the performance of two active arm movements: an arm elevation in the scapular plane, defined as 30° in front of the frontal plane (scaption task) and an arm elevation in the sagittal plane (forward flexion task). All measurements took place at the Clinical Motion Analysis Laboratory of the University Hospitals Leuven in campus Pellenberg (Belgium) 1 to 10 days prior and after the 12-week intervention period. Assessors were blinded for treatment allocation.

The movement analysis was preceded by three preparatory steps. First, while seated on a chair with low back support, clusters of three or four markers were placed on the sternum, scapula (flat part of the acromion), the upper arm (proximal, lateral) and lower arm (just proximal of ulnar and radial styloid processes), as visualized in Figure 1.

[insert Figure 1 here]

Second, the elevation distance and height were standardized (Figure 2). A bar, which indicated the elevation height, was installed by one researcher while another researcher passively elevated the arm of the participant. In both the scaption and forward flexion tasks, this was performed with an extended elbow and without allowing flexion, lateral bending, or axial rotation of the trunk until 120° of humerothoracic elevation was achieved.

Third, participants were asked to perform the scaption and forward flexion task actively, until they touched the bar - that was located at 120° of humerothoracic elevation - with the radial side of their index finger (Figure 2). The speed of movement was controlled by the researcher who counted. The arm was elevated in 3 seconds and lowered in 3 seconds. Hereafter, the participant kept the arm in the rest position alongside the thigh for 3 seconds before starting a new elevation/lowering movement. Several practice trials were performed to make sure participants understood the requested task. After the preparations, three recordings of four repetitions each were recorded per task.

[insert Figure 2 here]

After these movement trials, static trials were recorded in which anatomical landmarks were digitized and defined within their respective segmental marker cluster (CAST procedure) [23]. The anatomical landmarks were then used to construct anatomical coordinate systems and to calculate joint kinematics according to the ISB-guidelines [24]. The recorded movement data in this study were movement patterns of the humerothoracic joint (elevation/lowering, internal/external rotation), scapulothoracic joint (pro/retraction, lateral/medial rotation, ant/posterior tilting), trunk (flexion/extension, ipsilateral/contralateral lateral bending, ipsilateral/contralateral axial rotation) and elbow (flexion/extension, pro/supination).

Information about the cancer and its treatment was collected from the medical file of the participant. Other baseline characteristics including age, body mass index, and time since surgery were collected. Active humerothoracic forward flexion and abduction range of motion (°) was also measured with an inclinometer as part of the clinical examination. This was done in sitting position before and after the intervention [25].

Movement data analysis

Recorded movement data was processed with Matlab®, using U.L.E.M.A. [26]. Movement cycles were time-normalized and visualized from start to end point (from the moment the hand was moving until the hand was again placed next to the thigh). Out of the four repetitions (for each of the three recordings), the first and the last trial were eliminated because of potential interruption by initiation/completion strategies. Therefore, six repetitions per task were analyzed. The parameter of interest in this study was the complete movement pattern for each degree of freedom. Time-normalized kinematic waveforms (joint angles from start to end point of the task) of the humerothoracic joint, scapulothoracic joint, trunk, and elbow were visually checked for erroneous signals due to artifacts caused by marker occlusion. Erroneous recordings were excluded from the statistical analysis.

Statistical parametric mapping (SPM) was used to statistically analyze pre-post intervention differences in movement patterns at the level of the four joints between the groups (SPM_{1D} version 0.4 - MATLAB-based open-source software, available for download at http://www.spm1d.org/) [27]. The advantage of SPM_{1D} is that it allows hypothesis testing on continuous data without neglecting the interdependence between measures across different joint angles/time points. It uses Random Field Theory to estimate (1) the critical threshold above which only 5% (i.e., $\alpha = 0.05$) of equally smoothed random continuous data would be expected to cross, and (2) the probability that this would occur (i.e., p-value). For each task (scaption/ forward flexion), a two-way ANOVA (group x time) with one repeated measure was performed for each degree of freedom. A significant interaction effect, i.e. p-value below 0.05, would indicate that the two groups have responded differently to their respective interventions.

RESULTS

All women (n=169), referred by doctors, were screened for eligibility. A total of 82 women were eligible and 50 women (61%) agreed to participate. These women were randomized to an experimental group receiving myofascial therapy in addition to a standard physical therapy program (n=25) and a control group receiving placebo therapy in addition to the same standard physical therapy program (n=25). For the present secondary analyses, four participants were excluded because of erroneous signals in the kinematic data. This resulted in an experimental group of 22 participants and a control group of 24 participants. Baseline characteristics of the intervention and control group are given in Table 1.

The kinematic waveforms of the humerothoracic joint, scapulothoracic joint, trunk, and elbow are graphically represented for the scaption task in Figure 3 and for the forward flexion task in Figure 4.

No significant time and group effect was found (see Figures 3 and 4). A significant group x time interaction effect for scapulothoracic protraction/retraction was found during scaption, with a significantly reduced protraction post-experimental treatment at the mid-range of the arm elevation (p=0.049) and lowering phase (p = 0.043) (Figure 3). A significant group x time interaction effect was also found for scapulothoracic anterior/posterior tilting during forward flexion, with a significantly reduced anterior tilting post-experimental treatment at the beginning of the arm lowering phase (p = 0.049) (Figure 4). No significant interaction effects were found for other scapulothoracic movement patterns, humerothoracic joint, trunk, or elbow movement patterns in the scaption nor forward flexion task.

[insert Figure 3 and 4 here]

In Appendix A, the mean (SD) joint angles at each percentage of the movement cycle are additionally provided for both groups and both time points, for all degrees of freedom, for the scaption task. In Appendix B, this information is provided for the forward flexion task.

DISCUSSION

The aim of the present study was to explore if targeting soft-tissue restrictions with myofascial therapy, resulted in alterations in the movement patterns of the humerothoracic joint, scapulothoracic joint, trunk and elbow, on the long term after breast cancer treatment. The results show, in line with our hypothesis, a decreased scapulothoracic protraction and anterior tilting in women who received myofascial therapy in addition to a standard physical therapy in comparison to women who received a placebo treatment in addition to the same standard physical therapy program. In contrast to our hypothesis, no between-group differences in the movement patterns of the humerothoracic joint, trunk, or elbow were found.

For humerothoracic movements, a recent review with meta-analyses showed conflicting results for range of motion, assessed with clinical methods (e.g. goniometer) [20]. Beneficial effects of myofascial therapy were seen for abduction range of motion, but not for flexion, compared to placebo treatment or other interventions [20]. These results should be interpreted with caution since the low-methodological quality of the included studies and the wide variety in myofascial techniques used.

For scapulothoracic movements, results in the same sample of the present study (published elsewhere) showed no beneficial effects of myofascial therapy on clinical scapular static and dynamic outcome parameters [7]. The present study moves beyond traditional clinical range of motion parameters by using objective three-dimensional motion data and kinematic waveform analyses to improve understanding of these upper limb problems. Using this methodology, a decreased scapulothoracic protraction and anterior tilting after myofascial therapy was found. Possibly, the objective three-dimensional motion capture is a more sensitive and/or valid assessment method.

It is important to differentiate the significant results in scapulothoracic protraction during scaption and scapulothoracic posterior tilting during forward flexion. For scapulothoracic protraction, we see that both groups had similar values at baseline. Post-intervention, we see that the protraction angle has decreased in the experimental group, while it has increased in the control group. For scapulothoracic posterior tilting, the experimental and control group showed large differences at baseline. Post-intervention, the posterior tilting angle of the experimental group increased to values comparable to the control group. Despite these differences in the interpretation of the significant results, the evolution of the experimental group can be considered beneficial in both cases.

Results of the present study should be interpreted considering the following: First, regarding the included breast cancer population, women were 3 months or longer from breast cancer treatment. Potentially, soft-tissue stiffness/restrictions were present for too long to be resolved by myofascial techniques. Since the average time post-surgery was 3.03 (2.65) years, it can be assumed that the scars were fully healed and in the maturation phase, making it more difficult to influence elasticity and other soft tissue characteristics [28]. The participants also experienced pain and myofascial dysfunction in the affected upper limb region; however, the assessment of myofascial dysfunction was arbitrary assessed, i.e. yes or no. Since the severity of the myofascial restriction and their contribution to the participant's pain experience and altered movement patterns was not considered, these broad inclusion criteria could have allowed recruitment of a large number of non-responders to the myofascial therapy. Furthermore, large within-treatment group variability in movement patterns is observed. This might be due to the natural highly variable nature of movement patterns of the shoulder between individuals and the inconsistencies in shoulder movement patterns in persons with shoulder pain [29,30], but it might also rely on the different medical treatments that participants within one group received. Given the potential different effect of axillary and breast surgery or radiotherapy on soft-tissue structures and movement patterns of the shoulder, the medical treatment-related effect within each group can be larger than a potential between-group effect of the myofascial treatment. Second, regarding the applied methodology to assess the movement patterns, we adhered to the ISB standards for motion capture of the upper limb [24]; however, we only measured analytical tasks, i.e. scaption and forward flexion until 120 degrees. This upper limit was chosen because the applied acromion marker cluster only returns valid data until 120° of elevation [24]. This is clearly a shortcoming of the used methodology as a noteworthy treatment effect on movement patterns could possibly be observed only at higher ranges of motion. The applied physical therapy and myofascial techniques focused on improving range of motion at the end of the available range of motion. As seen from the baseline characteristics (Table 1), the women included in this research were generally able to elevate the arm more than 120°. It is possible that additional treatment effects occur beyond 120° of arm elevation. Third, although the present analysis provides novel insights in movement patterns in a sample of women after breast cancer, one could question whether it is possible to assess natural movement behavior in a motion laboratory environment. The analytical tasks used in the present study may not capture the complexity of shoulder movement behavior during daily life activities. Other less-obtrusive motion capture systems, such-as inertial sensors, might be more able to effectively capture natural movement patterns during the performance of functional tasks [31]. The disadvantage of functional tasks related to marker occlusion in a movement laboratory environment are excluded by using inertial sensors.

Strengths and limitations

T**he strengths** of this research should be pointed out. Thus was a double-blind, randomized, controlled trial. The participants in these two groups received the same amount of the individual standard physical therapy program, which was 20 sessions in total. The intervention group received 12 sessions of myofascial therapy and the participants in the control group received 12 sessions of placebo therapy. Treatment programs were therefore similar between two groups. Furthermore, this is the first study that made use of SPM for the statistical analysis of the movement patterns. Not only does SPM allow to analyze the entire waveform at once, it is also statistically more robust than the analysis of discrete values extracted from the waveform [27]. However, also SPM comes with its limitations. Although it is well suited to grasp the interaction between the different timepoints of the kinematic waveforms, it can only analyze one degree of freedom at the time. To fully grasp the interdependency between different degrees of freedom within a joint and between joints, more complex statistical approaches might be used in future research. As a limitation, it must be noted that these were exploratory secondary analyses with no sample size calculation and possibly not enough power to detect differences between group. Further, limitations related to the 3D-assessment method and laboratory setting discussed above should be considered as well.

Clinical implications

In the sample of women used for this secondary analysis, a short-term effect of additional myofascial therapy was found on pain intensity after three months. These effects did not persist on the long-term [21]. With the knowledge of the beneficial effects on scapulothoracic motion in mind, it should be explored to which extend the alterations in movement patterns at the level of the scapula contribute to the short-term decrease in pain intensity, or vice versa. While some evidence suggests an interaction between pain and movement patterns [32,33], other research in musculoskeletal shoulder pain showed that alterations in scapulothoracic kinematics are not related to alterations in pain intensity following a physical therapy intervention [34,35]. Also in the (breast) cancer population, pain is considered to be a complex and multifactorial experience [36]. Given this, psychosocial contributors, including anxiety, depression, and stress among others, to (persistent) pain have to be considered, drawing attention to a shift from a biomedical explanation of persistent pain to a comprehensive biopsychosocial approach [37].

Conclusion

This research has collected an extensive dataset on 3D humerothoracic, scapulothoracic, trunk, and elbow movement patterns. Based on these data, myofascial therapy in addition to a 12-week standard physical therapy program seems to have beneficial effects on scapulothoracic movement patterns in women with pain and myofascial dysfunction at the affected upper limb region on the long term after breast cancer surgery. Movement patterns at the humerothoracic joint, trunk, and elbow did not change after myofascial therapy. The clinical relevance of this finding needs to be further explored considering the complex nature of shoulder kinematics and pain and the exploratory character of the reported analyses.

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DECLARATION OF INTEREST

Declarations of interest: none

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TABLES

Table 1. Baseline characteristics of women according to treatment allocation. Mean (SD) and frequency (%) are given.

	Experimental group (n=22)	Control group (n=24)
Mean (SD) age (years)	54.81(7.74)	52.62 (7.20)
Mean (SD) BMI (kg/m2)	28.81(4.66)	25.42 (4.15)
Mean (SD) time since surgery (years)	3.03 (2.65)	3.05 (3.52)
Operated on dominant side (%)	10 (46%)	10 (42%)
Lymph node stage (%)		
pN0	11 (50%)	15 (63%)
pN1	7 (32%)	8 (33%)
pN2	3 (14%)	0 (0%)
pN3	1 (5%)	1 (4%)
Tumor size (%)		
pT0	0	2 (8%)
pT1	12 (55%)	6 (25%)
pT2	9 (41%)	11 (46%)
pT3	1 (4%)	3 (13%)
pT4	0	2 (8%)
Type of cancer therapy (%)		
Breast surgery		
Mastectomy	14 (64%)	18 (75%)
Breast conserving surgery	8 (36%)	6 (25%)
Axillary surgery		
Level I	4 (18%)	6 (25%)
Level I-II	8 (37%)	7 (29%)
Level II-III	9 (41%)	11 (46%)
Radiotherapy	22 (100%)	23 (96%)
Chemotherapy	14 (64%)	15 (63%)
Neoadjuvant chemotherapy	2 (9%)	3 (13%)
Hormonal therapy	19 (85%)	22 (92%)
Targeted therapy	3 (14%)	3 (13%)
Active humerothoracic range of Motion (inclinometry)		
Mean (SD) Forward flexion – pre(°)	148 (13)	133 (25)
Mean (SD) Forward flexion – post(°)	155 (14)	146 (22)
Mean (SD) Abduction – pre(°)	125 (20)	115 (29)
Mean (SD) Abduction - post(°)	143 (16)	133 (28)

BMI: body mass index, SD: standard deviation

FIGURES

Figure 1. Cluster placement

Figure 2. Standardization of the participants and the forward flexion task execution

Figure 3. Kinematic waveforms of A) the trunk, B) the humerothoracic joint, C) the scapulothoracic joint and D) elbow for the scaption task

Figure 4. Kinematic waveforms of A) the trunk, B) the humerothoracic joint, C) the scapulothoracic joint and D) elbow for the forward flexion task

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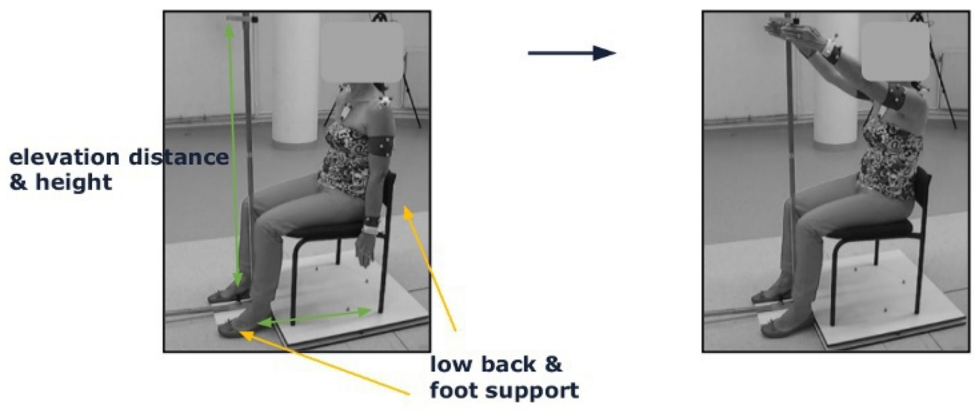

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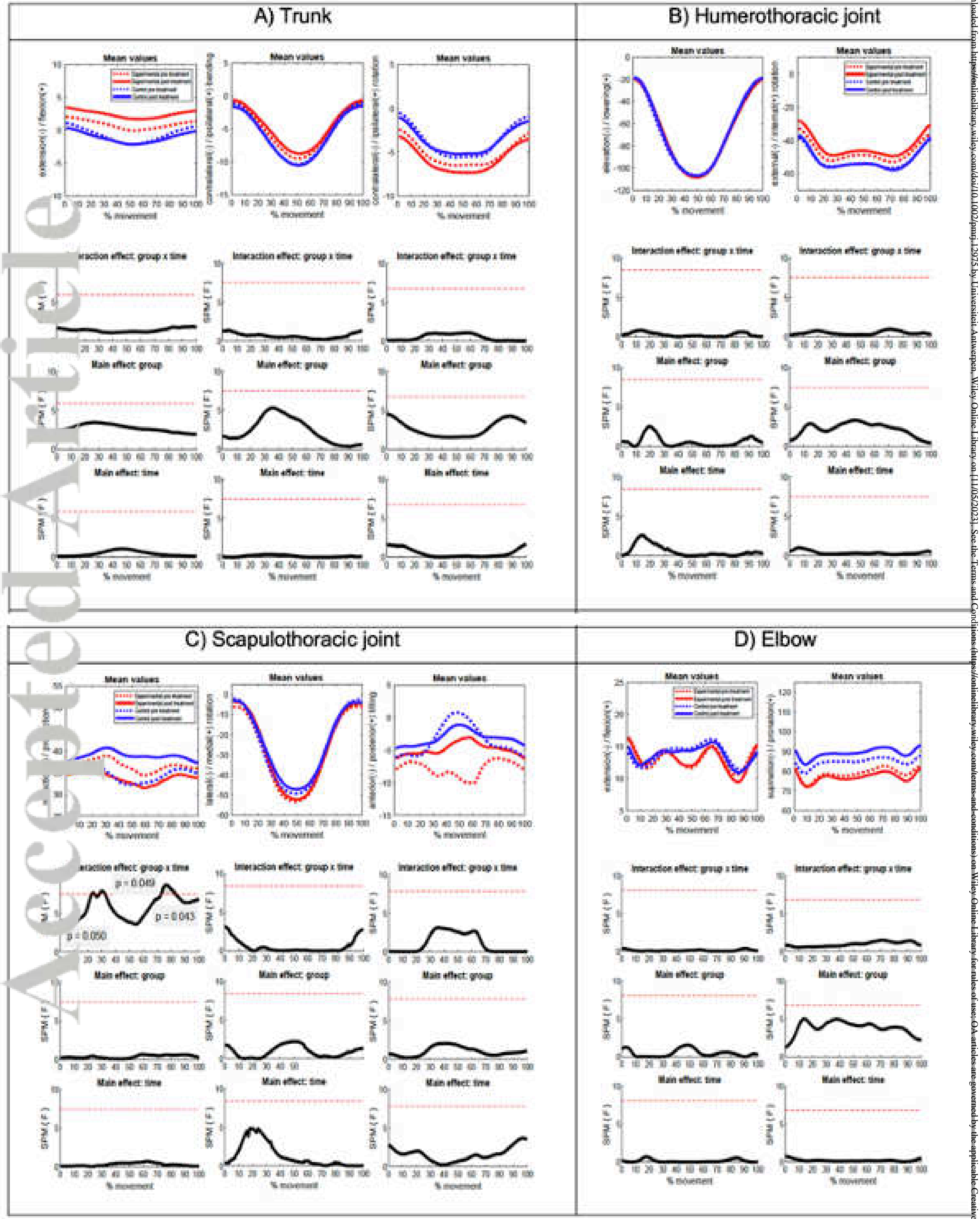

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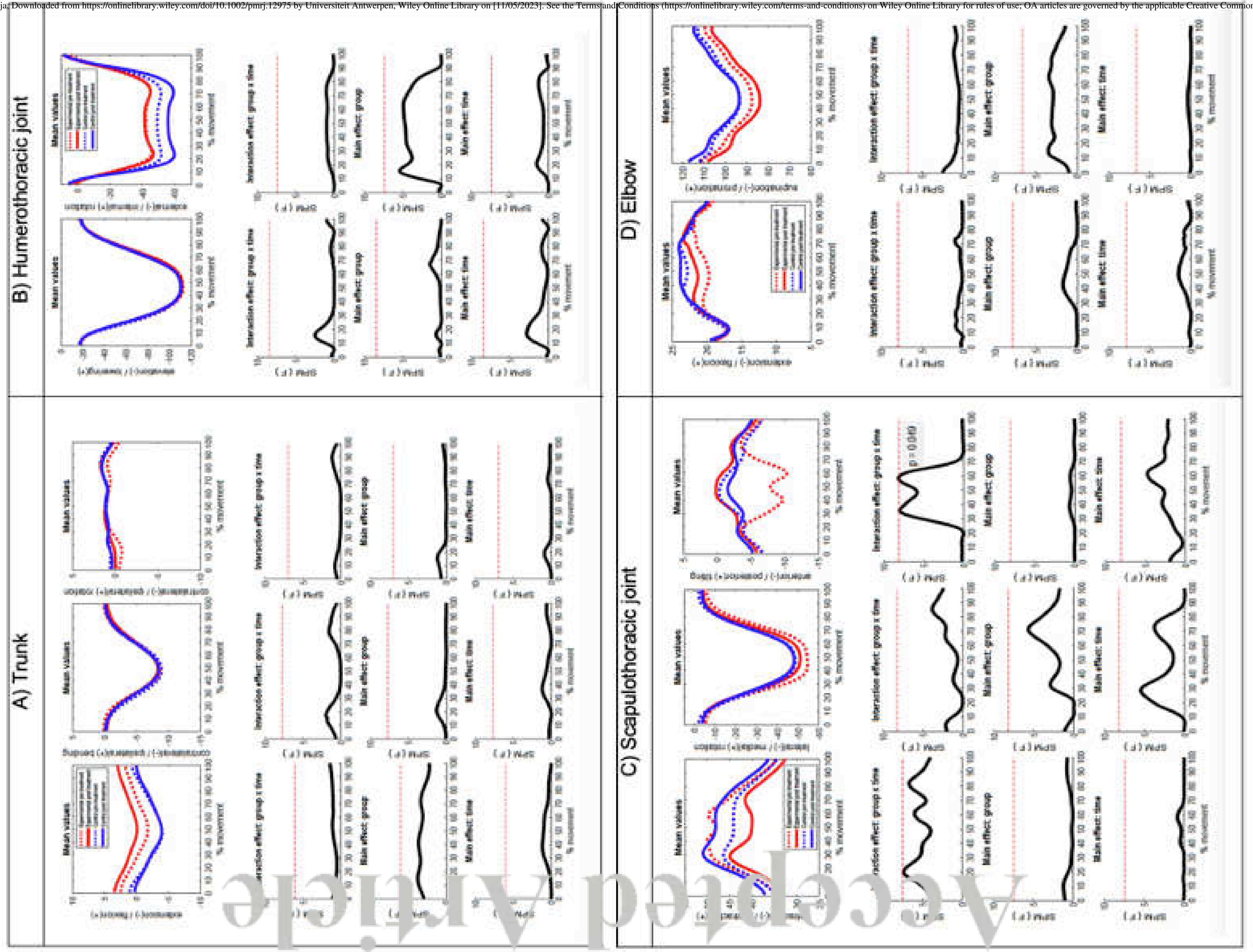

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