Energy expenditure during functional daily life performances in patients with fibromyalgia

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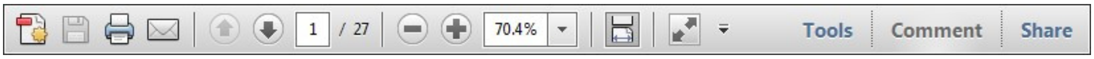

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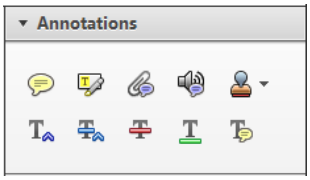

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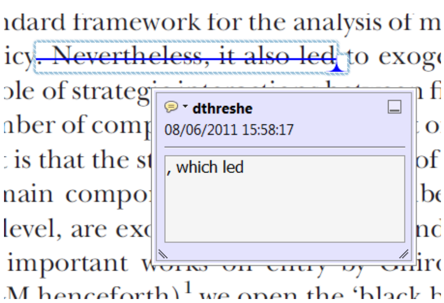

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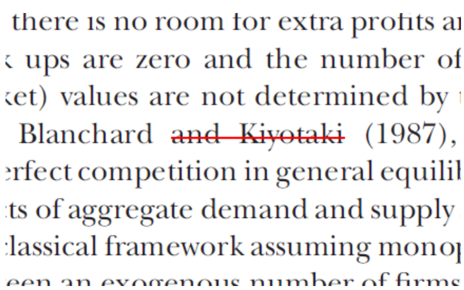

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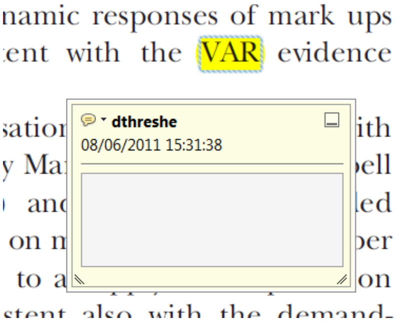

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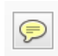

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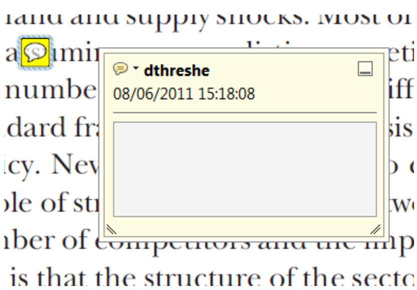

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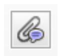

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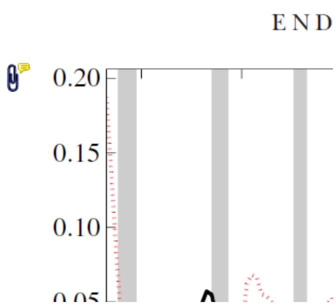

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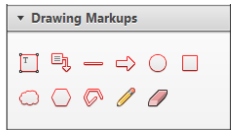

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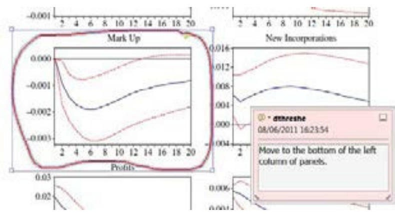

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ORIGINAL ARTICLE

Energy Expenditure during Functional Daily Life Performances in Patients with Fibromyalgia

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■ Abstract

Objective: The objective of this study was to evaluate whether patients with fibromyalgia FM need more oxygen and more time to complete a walking and stair-climbing task than healthy volunteers and perceive the performance of these tasks as more strenuous. Furthermore, it was evaluated whether a less efficient performance is more pronounced in patients reporting a higher level of fear of movement.

Methods: Thirty patients with FM and 30 matched healthy volunteers completed a 500-meter walking and a stair-climbing task (60 steps) while wearing a mobile gas analyzing unit. Mean and total oxygen consumption and time needed to complete each task were recorded. After both tasks, a Borg score was used to measure perceived exertion. Fear of movement was measured with the Tampa Scale for Kinesiophobia.

Results: Patients with FM needed more time to complete the walking and stair-climbing task and reported higher levels of exertion compared to healthy volunteers. However, the total oxygen consumption for performing both tasks was not different. In patients with FM, a higher level of fear of movement was associated with a higher perceived exertion after the walking task. Interestingly, a higher somatic focus is related to a lower mean oxygen consumption needed to perform the stair-climbing task.

Conclusion: In conclusion, patients with FM perceive a walking and stair-climbing task as more strenuous than healthy controls, even though they walked slower and no differences in total O_2 consumption during completion of both tasks were found. ■

Key Words: fibromyalgia, functional daily tasks, energy expenditure, fear of movement

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INTRODUCTION

Fibromyalgia (FM) is a chronic pain syndrome with widespread musculoskeletal pain, multiple tender points, and fatigue among its key features.[1] Evidence has been found for hypersensitivity of the central nervous system or central sensitization in FM resulting in the persistence of pain.[2–4] Additionally, activation of endogenous pain inhibition after exercise as has been found in healthy individuals was not found in patients.[5] Instead of exercise-induced analgesia, most patients even report an increase in pain after exercise. Patients may avoid this dysfunctional response and as a result, a decrease in the level of physical functioning and physical deconditioning is to be expected.[5] Whereas a lower level of perceived physical functioning in patients with FM has indeed been confirmed,[6] the evidence for physical deconditioning is still unclear.[7]

According to Vlaeyen et al.[8], physical deconditioning is a result of long-term disuse defined as the reduced and altered use of the musculoskeletal system during daily life activities. In the fear-avoidance model, it is hypothesized that pain causes reduced use, but also altered use such as impaired muscle coordination leading to guarded movements.[8] Earlier studies in patients with FM indeed report altered use of the musculoskeletal system: During walking a reduced speed, a higher double support phase and lower stride length were found compared to healthy individuals.[9] Furthermore, although several gait parameters (ie, temporal, spatial, kinematic, and ground reaction force patterns) were similar in patients with FM and healthy individuals, the internal muscle recruitment pattern of women with FM (ie, hip and ankle moment and power patterns) was significantly different from the patterns used by healthy controls.[10] In fact, the muscle recruitment pattern used by women with FM while walking at their preferred comfortable speed resembles the pattern used by the control group while walking fast. It might be that the altered muscle recruitment pattern of patients with FM results in a less efficient performance of activities during daily life activities. If this is the case, patients with FM will need more energy to perform regular daily activities as compared to controls. This assumption would thus be in line with the finding that physical deconditioning in FM does not occur or is less than expected.[8] Moreover, as performing regular daily life activities in this adapted way will cost patients with FM more energy, this could, also explain why these patients report higher levels of fatigue in daily life.

In the last decades, it became clear that a patient's pain behavior also depends on psychological and social factors. In patients with FM, it has been found that pain-related fear is associated with a higher disability level.[11] As proposed in the fear-avoidance model of chronic pain, people who react in a fearful way to pain will avoid normal performance of activities that are expected to be painful or harmful.[8] This avoidance of activities is assumed to result in disuse, depression, and disability. These negative consequences are proposed to maintain the pain experiences and thereby a vicious circle of increasing fear and avoidance arises.[8] Based on this, it can be hypothesized that inefficient performance as a result of guarded movements, a characteristic of disuse, will be especially present in patients with FM reporting higher levels of pain-related fear.

To test these hypotheses, the first purpose of this study is to determine whether patients with FM have higher oxygen consumption during the performance of functional daily tasks such as walking and stair-climbing compared to age and gender-matched pain-free controls. In addition, it will be evaluated whether patients with FM need more time to complete these tasks and report a higher level of fatigue after performing the tasks compared to matched healthy controls. The second purpose is to determine whether a higher level of fear of movement is associated with higher oxygen consumption to perform these tasks, a higher level of fatigue after performing the tasks and more time to complete the tasks.

METHODS

Participants

Patients diagnosed with FM according to the ACR criteria[12] who participated in an earlier research project that compared the effectiveness of the multidisciplinary intervention with aerobic exercise and usual care (M. Kroese; MEC 03-172 "Evaluation of health care innovations in fibromyalgia"[13]) who still reported to have pain and gave permission to be contacted again for future research were asked to participate in the current study. Age and gender-matched healthy controls were recruited by advertisement.

Patients with FM and healthy controls were included according to the following criteria: (1) Patients were diagnosed with FM and no other known specific pathology that may cause the pain and healthy controls did not suffer from musculoskeletal pain problems, (2) all participants were aged between 18 and 65 years, (3) participants were able to walk 500 meter without walking aids and walk 60 stair steps with the use of one handrail (resting during these activities is allowed).

Patients and healthy controls were excluded from the study if they matched one of the following criteria: (1) the use of beta-blockers, (2) comorbidity hampering gas analyses, such as COPD or other lung conditions that require treatment by a lung specialist, (3) pregnancy, and (4) nonfluency in Dutch.

The study was approved by the Medical Ethics committee Maastricht University/Maastricht University Medical Centre (METC 12-3-004). All participants gave written informed consent before participating in this study.

Study Procedure

First, demographic information was recorded and questionnaires were filled out. Gender, age, level of education, and work status were recorded. Secondly, the height, weight, and lean body mass (LBM) were measured. Thirdly, the Oxycon Mobile was put on. After the mobile device was carefully fitted to the participant, a resting period of at least 3 minutes started during which the participant was asked to sit quietly without speaking. After a steady heart rate (maximal variation of ± 5 during 3 minutes) was reached, the first task was executed. After finishing the first task, the device remained in place, and before the start of the second task, another resting period started until a steady heart rate was reached. A 500-meter walking task and a 60 steps stair-climbing task were conducted; the order of these 2 tasks was determined by randomization with a computer. The healthy volunteers performed the tasks in the same order as the patients with FM they had been matched with. Participants were instructed to walk at their own, comfortable speed to resemble daily life performance.

Measures

Functional Daily Tasks. As in this study, the O_2 uptake during functional daily tasks was focussed upon, O_2 uptake was assessed during 2 often performed daily life activities: walking and stair-climbing.

Walking Task – In earlier studies, the average distance covered by patients with FM during the 6-minute walk test ranged from 432 to 530 meters.[14–16] Therefore, in the current study, 500 meter was set as the walking distance to be completed. Walking aids were not allowed during the test, and participants were instructed to walk at a self-chosen, comfortable speed. The time needed to complete 500 meter was recorded. Participants were allowed to rest during the task.

Stair-climbing Task – In a recent study, it was found that patients with chronic musculoskeletal pain who had to climb stairs up and down during 1 minute, covered 73.90 steps (SD = 28.8).[17] For this reason, participants were instructed to walk 3 times up and down a 10 step high stair at a self-chosen, comfortable speed. In this way, they climbed/descended a total of 60 steps. Participants were allowed to use the handrail on 1 side. The time needed to complete this task was recorded. Participants were allowed to rest during the task.

Body Composition

Participants were weighed without shoes before the first task. The percentage of body fat was measured using a body fat monitor (Omron BF306). Participants were instructed to avoid drinking more than 2 units of alcohol the day prior to the measurement and not to perform heavy exercise on the day they were tested. The mean body fat percentage of 2 measurements was used to calculate LBM as follows: LBM = total body weight—(%mean body fat*total body weight).

Oxygen Consumption

During functional daily tasks, a portable breath-by-breath analyzer (Oxycon Mobile [V-781023-053 by CareFusion]) was used to assess the participant's gas exchange. This mobile device consists of a facemask with integrated oxygen (O_2) and carbon dioxide (CO_2) electrodes, a data exchange unit, a transmitting unit, and a receiving unit. It weighs 950 g and was worn on the back. The equipment has an acclimatization time of 15 minutes. Calibration was performed before each measurement. A wide range of VO_2 can be measured accurately during different exercise intensities with the Oxycon Mobile.[18]

O_2 uptake was measured breath-by-breath during the performance of the complete task and averaged over 5 second periods for data analysis. The mean O_2 consumption per minute was calculated based on this 5 second epochs. This mean O_2 consumption was multiplied with the total time needed to complete the task to calculate the total amount of O_2 needed to perform the task. To adjust for potential differences in body composition, the O_2 outcome variables are presented in mL per kg LBM. For both functional daily tasks, energy expenditure is reflected by 2 outcome variables; the mean O_2 consumption per minute in mL/kgLBM/minute and the total amount of O_2 needed to perform the task in mL/kgLBM.

Questionnaires

The following parameters were only recorded for patients with FM:

Pain Intensity. Patients were asked to rate their actual pain (at that moment) and their highest and lowest pain level of the past week on 3 separate 100 mm VAS scales.[19] The mean of the 3 VAS scales was calculated to form a composite score. In addition, after performing the walking as well as the stair-climbing task, pain intensity during performing the task was rated on a 100 mm VAS scale.

Catastrophizing Thoughts about Pain. The Pain Catastrophizing Scale (PCS) consists of 13 items that make a statement regarding thoughts about pain. Patients rate on a 5-point Likert scale how much they agree with the statement (0 = not at all and 4 = always). The psychometric properties (ie, validity and reliability) of the PCS are well documented and supported.[20–22]

Fear of Movement. Fear of movement/(re)injury was assessed with the Dutch version of the Tampa Scale for Kinesiophobia (TSK). This questionnaire contains 17 items that are rated on a 4-point scale ranging from "strongly disagree" to "strongly agree". The total score ranges between 17 and 68. Previous research supported an activity avoidance (TSK-AA) and somatic focus subscale (TSK-SF).[23,24] The Dutch version has been reported to be reliable and valid.[25,26]

Disability. Disability was assessed using the Dutch version of the Pain Disability Index (PDI).[27] Reliability and validity of the PDI were judged as satisfactory.[28] Patients rate on a scale of 0 (no disability) to 10 (totally disabled) how disabled they are in each of the following life domains: family/home responsibilities, recreation, social activity, occupation, sexual behavior, self-care, and life supporting activities. The total PDI score varies from 0 to 70.

The following parameters were recorded for FM patients and healthy subjects:

Habitual Activity Level – The physical activity level was measured through the Baecke Physical Activity Questionnaire (BPAQ).[29] The BPAQ consists of 3 indices of habitual physical activity: The occupational activity index, sport activity index, and the leisure time index. The reliability of the BPAQ in patients with pain appears to be sufficient.[30]

Perceived Exertion – After each test, the perceived exertion was assessed by Borg's 6–20 rating of perceived exertion (RPE) scale.[31]

Statistical Analysis

To study the difference in oxygen consumption, time to complete the task, and perceived exertion measured after performing the walking and the stair-climbing task between patients with FM and healthy controls, a paired sample *t*-test was used in case of a normal distribution. In case of non-normal distributions of the data, the Mann–Whitney *U*-test was used.

A Spearman correlation coefficient was used to evaluate the association between fear of movement (total score and subscales TSK-AA TSK-SF) and the O_2 consumption (mean and total O_2) during the performance of the walking and stair-climbing task.

In addition, a Spearman correlation will be used to perform a post hoc analysis to evaluate the association between the level of perceived exertion and the increase in pain during performing both tasks. The increase in pain intensity was calculated by subtracting the pain intensity scored before the performance tasks from the pain intensity scored directly after the walking and stair-climbing task.

All statistical analyses were performed using IBM SPSS Statistics version 19.

RESULTS

In Figure 1, a flow chart is shown, representing the patient inclusion pathway in the current study. Finally, 30 patients with FM (27 female) were tested and 30 age and gender-matched healthy controls were included in this study. Mean age of the patients with FM was 47.0 years (SD = 9.3). Patients with FM had a higher body weight (81.1 kg vs. 67.0 kg; $P < 0.01$) and a higher LBM ($P < 0.05$) as compared to the healthy controls. Compared to the healthy controls, a lower percentage of the patients with FM had a paid job (47% vs. 77%), and more patients with FM received a disability payment (8 vs. 1). Table 1 presents the other characteristics of the 30 patients with FM and 30 healthy controls.

Differences in Performance-related Outcomes between Healthy Controls and Patients with FM

Table 2 presents the scores on the performance-related outcomes for healthy controls and patients with FM. In patients with FM, a significantly higher Borg score was found after both the walking ($P < 0.01$) and stair-climbing task ($P < 0.01$) compared to healthy controls, indicating that the patients perceived both tasks as

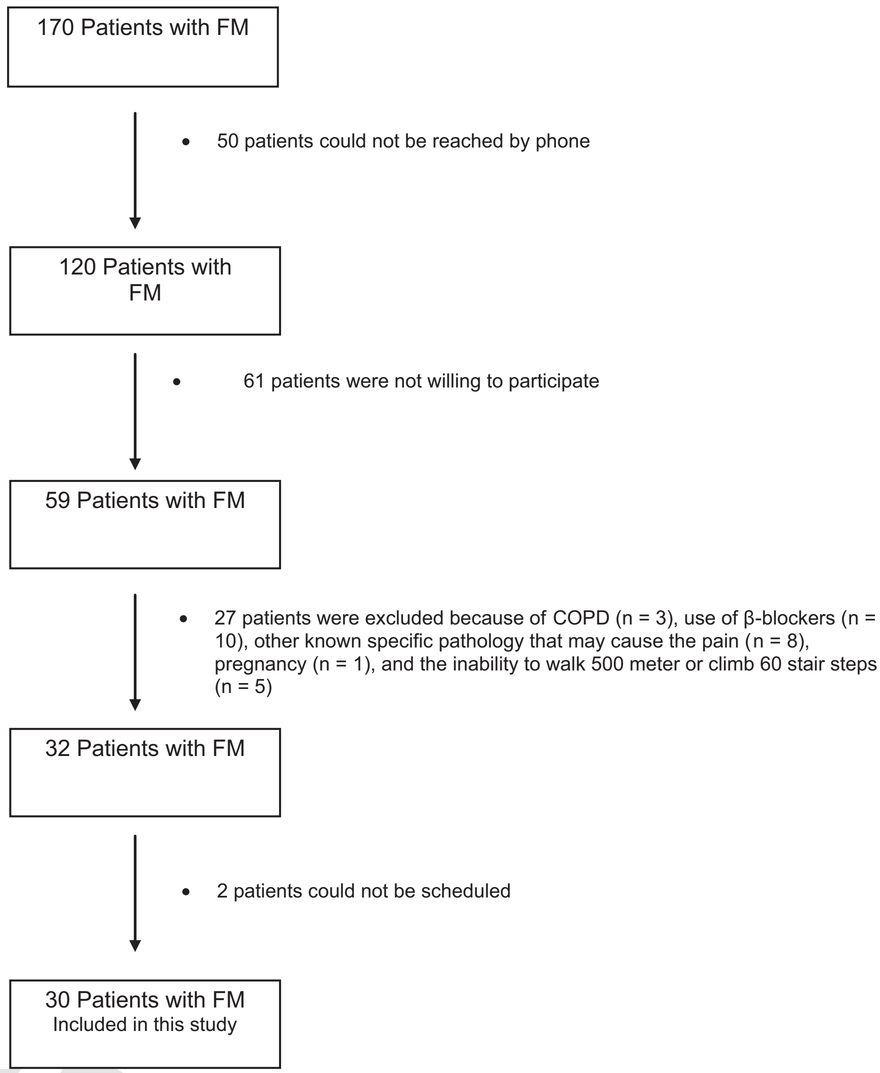

Figure 1. Flow chart.

more strenuous. In addition, it took patients with FM more time to complete the walking ($P < 0.05$) and stair-climbing task ($P < 0.01$). However, the mean O_2 consumption expressed as O_2 per minute in mL/kgLBM/minute of the stair-climbing task was significantly lower in patients with FM compared to healthy controls ($P < 0.01$). No significant difference was found for the total O_2 consumption in mL/kgLBM during stair-climbing, and also, no significant differences were found on the mean and total O_2 consumption during walking.

The Association between Fear of Movement and Performance-related Outcomes for Patients with FM

Table 3 presents the results of the association between fear of movement and performance-related outcomes. The Borg score after completion of the walking task and the TSK total score (Spearman's rho = 0.45, $P = 0.01$) and TSK-AA score (Spearman's rho = 0.40, $P < 0.05$) were significantly correlated. Furthermore, the TSK-AA score was significantly associated with the time to complete the walking task (Spearman's rho = 0.39, $P < 0.05$), and the TSK-SF score was negatively related to the mean O_2 consumption needed to perform the stair-climbing task (Spearman's rho = −0.38, $P < 0.05$). No other significant associations were found between fear of movement and oxygen consumption.

Post hoc analyses revealed that the level of perceived exertion was associated with the increase in pain intensity during both the walking (Spearman's rho = 0.48, $P = 0.01$) and stair-climbing task (Spearman's rho = 0.39, $P = 0.04$).

Table 1. Characteristics of the Study Population

	Healthy Controls (n = 30)	Fibromyalgia (n = 30)
Male/female	3/27	3/27
Age	45.4 (10.4)	47.0 (9.3)
Body weight (kg)	67.0 (9.2)	81.1 (17.4)
Length (cm)	168.7 (7.6)	170.4 (7.6)
Lean body mass (kg)	46.8 (7.2)	51.0 (8.0)
Work status (%)		
Paid job	23 (77)	14 (47)
Sick leave	0	2 (7)
Disability payment	1 (3)	8 (27)
Habitual activity level (BPAQ)	8.6 (1.1)	8.7 (1.5)
Work	2.6 (0.5)	3.0 (0.8)
Sport	2.8 (0.7)	2.6 (0.7)
Leisure time	3.3 (0.6)	3.1 (0.7)
Measures only recorded in fibromyalgia patients		
Disability level (PDI)		30.1 (12.4)
Pain catastrophizing (PCS)		9 (6 to 21)
Fear of movement (TSK)		33.5 (6.9)
Pain Intensity		5.4 (1.7)

BPAQ, Baecke Physical Activity Questionnaire; PDI, Pain Disability Index; PCS, Pain Catastrophizing Scale; TSK, Tampa Scale for Kinesiophobia.
Normally distributed data are represented by means (SD), and not normally distributed data are represented by medians (interquartile ranges).

Table 2. Performance-related Outcomes for Healthy Controls and Participants with Fibromyalgia

	Healthy Controls (n = 30)	Fibromyalgia (n = 30)	P-value
Mean O_2 walking (mL/kgLBM/minute)	2.5 (2.1 to 2.8)	2.2 (1.9 to 2.6)	ns
Mean O_2 stair-climbing (mL/kgLBM/minute)	26.2 (21.7 to 28.9)	20.7 (19.1 to 22.6)	< 0.01
Total O_2 walking (mL/kgLBM)	18.8 (17.4 to 21.1)	18.5 (17.0 to 20.3)	ns
Total O_2 stair-climbing (mL/kgLBM)	15.8 (14.0 to 17.2)	15.2 (14.0 to 17.3)	ns
Time to complete walking task (seconds)	464.1 (56.9)	498.0 (60.8)	< 0.05
Time to complete stair-climbing task (seconds)	36.9 (7.2)	45.6 (8.0)	< 0.01
Borg score walking	9 (7 to 10.3)	11 (9 to 13)	< 0.01
Borg score stair-climbing	9 (7 to 11)	11 (11 to 13)	< 0.01

Normally distributed data are represented by means (SD), and not normally distributed data are represented by medians (interquartile ranges).

DISCUSSION

This study aimed to evaluate whether patients with FM need more oxygen and more time to complete a walking and stair-climbing task than healthy volunteers and whether they perceive these tasks as more strenuous. Furthermore, it was evaluated whether patients with more fear of movement move less efficient during performing both tasks.

Table 3. Spearman's Correlations between Fear of Movement and Performance-related Outcomes for Patients with Fibromyalgia

	TSK	TSK-AA	TSK-SF
Borg score walking	0.45**	0.40*	0.34
Borg score stair-climbing	0.15	0.22	0.21
Mean O_2 walking	−0.21	−0.31	−0.23
Mean O_2 stair-climbing	−0.27	−0.22	−0.38*
Total O_2 walking	−0.04	−0.11	−0.14
Total O_2 stair-climbing	−0.17	−0.08	−0.33
Time to complete walking task (second)	0.28	0.39*	0.16
Time to complete stair-climbing task (second)	0.12	0.14	0.10

*P < 0.05.
**P = 0.01.
TSK, Tampa Scale for Kinesiophobia; TSK-AA, Tampa Scale for Kinesiophobia activity avoidance; TSK-SF, Tampa Scale for Kinesiophobia somatic focus.

The results of the present study showed that patients with FM perceive a walking and stair-climbing task as more strenuous than healthy controls, even though they walked slower and no differences in total O_2 consumption during completion of both tasks were found. Perceiving both tasks as more strenuous and taking more time to complete both tasks seem in line with a recent study evaluating the performance of women with FM on the 6-minute walking test showing that the distance walked was lower and the perceived exertion was higher in patients with FM compared to healthy controls.[32] A potential limitation of the current study is the instruction given to the participants. Participants were instructed to walk at their own, comfortable pace to resemble daily life performance. Performing these activities more slowly, as the patients with FM did, could be a way to preserve energy. However, it is remarkable that no differences in total O_2 consumption during completion of both tasks were found. For future research, it is interesting to measure the oxygen consumption in patients with FM while walking at the same speed as the healthy volunteers they are matched with. When in this situation, the total oxygen consumption of patients with FM would be higher compared to that of healthy volunteers the difference might be related to the different muscle recruitment pattern as described in the introduction or related to deconditioning arising from long-term reduced use of the musculoskeletal system.[10]

Interestingly, the mean O_2 consumption per minute during the stair-climbing task was significantly lower in patients with FM compared to healthy controls. An explanation might be that patients with FM perform the task at a slower pace, resulting in more time to complete the task and thus a lower mean O_2 consumption per kg

LBM per minute. Nevertheless, it remains striking that patients with FM perceive both tasks as more exerting. Similar results have been reported in a study of Nielens et al.[33] They found that the cardiorespiratory fitness of patients with FM and matched healthy controls did not differ, but patients with FM perceived the used ergometer test as more exerting. The post hoc analyses of our study data revealed that the level of perceived exertion was associated with the increase in pain intensity during performing both tasks. The experienced pain might interfere with the perceived exertion. One mechanism that might explain the higher level of experienced exertion and significant correlation with pain intensity is the process of central sensitization.[34] A characteristic of central sensitization is an increased bottom-up activity and/or altered top-down pain modulation characterized by increased activity of pain facilitation pathways or reduced descending pain inhibition, resulting in enhanced temporal summation of secondary pain (wind-up). This mechanism might explain the increase in pain after performing both tasks.[2,35] Unfortunately, in this study, we did not measure pain increase before and during both task performances. In contrast, in healthy control subjects exercise will activate endogenous pain inhibition, leading to a higher tolerance and greater well-being and lower perceived exertion afterward [13] . Whether this mechanism is the reason for the reported symptoms in these regular daily life activities should be further explored.

Based on the fear-avoidance model, it was assumed that pain-related fear would have a negative impact on the efficiency of walking and stair-climbing performance. It was hypothesized that a higher level of fear is associated with a less efficient way of performing daily activities resulting in more oxygen consumption, due to guarded movement. However, this assumption could not be fully confirmed. It was found that fear of movement indeed had an impact on the level of perceived exertion after the walking task and was associated with more time needed to complete the walking task. However, the hypothesis that a higher level of fear of movement is associated with a higher level of oxygen consumption during task performance could not be confirmed. In addition and against our hypothesis, it was found that a lower mean oxygen consumption during stair-climbing, probably as a result of the more comfortable pace, was associated with a higher level of the somatic focus of the patient (as measured by the subscale of the TSK). A possible explanation for this finding might be that more somatic focus of a patient results in adaptation of task performance resulting in a slower pace. However, a similar association between somatic focus and time to complete the stair-climbing task could not be found.

It is remarkable that in the present study, patients with FM report lower scores on fear of movement, measured by the TSK, compared to patients with FM in other studies[23,36,37] and patients with other chronic musculoskeletal pain conditions such as CLBP and complex regional pain syndrome.[23,36–38] These lower TSK-scores may imply that our population of patients with FM has less harmful thoughts. This might be a reason why, due to restrictions in the continuum of scores for pain-related fear, no effect of fear of movement on the total oxygen consumption needed to perform the walking and stair-climbing task could be found. The avoidance of activities subscale of the TSK was found to be related to more time needed to complete the walking task. This finding is in line with results of a study of Turk et al.[11], showing that patients with FM having a high pain-related fear level showed a poorer treadmill performance, quantified as speed x duration, compared to patients having a lower level of pain-related fear. However, it is striking that the avoidance of activities subscale is not related to the time needed to complete that stair-climbing task. More research on the role of fear of movement in patients with FM is needed.

Another point to discuss regarding this study is the higher body weight and lean body mass in the patients with FM compared to the healthy controls. To adjust for this difference, oxygen consumption was presented in mL per kg LBM. However, the higher body weight might have influence on the time needed to perform the walking and stair-climbing task.

The current study findings have clinical implications for the interpretation of the outcome of functional performance tasks in daily practice. Based on the results of the current study, it can be concluded that patients with FM perform daily life activities at a slower comfortable pace compared to healthy controls. Although they perceived these tasks as more strenuous, the total level of oxygen consumption is not different. For clinical practice, it might be useful to measure a patient's perceived exertion level and the objectively registered energy expenditure as a measure of the actual exertion level during performing daily life performances. This might be supportive in giving feedback on a patient's actual functioning and helpful in designing the patient's treatment.

CONCLUSION

In conclusion, patients with FM need more time to complete daily life activities (walking and stair-climbing) and report more exertion after performing these activities compared to healthy volunteers. However, the total oxygen consumption for performing both activities was not different from that of healthy controls. In patients with FM, a higher level of fear of movement was associated with more time needed to complete the walking task and they perceived the walking task as more strenuous afterward. Interestingly, the somatic focus of a patient is related to a lower mean oxygen consumption during the walking task.

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