Association between chronic pain and physical activity in a Swiss population-based cohort: a cross-sectional study

Oriane Aebischer, Marc René Suter, Peter Vollenweider, Pedro Marques-Vidal

ABSTRACT

Objective To assess the bidirectional association between chronic pain and both subjectively and objectively measured physical activity (PA).

Design Cross-sectional study.

Setting Population-based sample in Lausanne, Switzerland, May 2014 to April 2017.

Participants Non-stratified, representative sample of the population of Lausanne (Switzerland) aged 35–75 years. Participants were excluded if they had missing data for the pain or the PA questionnaires, for accelerometer (defined as >20% of non-wear time or duration <7 days) or for covariates.

Primary outcomes Primary outcomes were association between chronic pain and previous, subjectively assessed PA (questionnaire), and subsequent, objectively assessed PA (accelerometry). Daily pain, pain duration, number of painful sites and pain intensity were assessed by questionnaire. PA was assessed by questionnaire 2 weeks prior and by accelerometer 2 weeks after completion of the pain questionnaire. PA was further categorised as sedentary (SED), light and moderate-to-vigorous PA.

Results 2598 participants (52.9% women, mean age 60.5 years) had subjectively assessed PA. Multivariable analysis showed time spent in sedentary PA to be negatively associated with the number of painful sites: adjusted mean±SE 528±5, 522±7 and 502±7 min/day for 0, 1–2 and 3+ painful sites, respectively, p for trend <0.005. No other association was found between chronic pain and subjectively assessed PA categories. 2205 participants (52.8% women, mean age 61.7 years) had accelerometer-derived PA. No significant association between chronic pain and subsequent objectively assessed PA was found after multivariable analyses.

Conclusion In this Swiss population-based cohort, no consistent association was found between chronic pain and PA. Hence, in the general population, chronic pain does not significantly impact time spent in PA.

INTRODUCTION

The relationship between chronic pain and physical activity (PA) in the general population is of public health interest. Severe chronic pain and widespread pain increase all-cause and cardiovascular mortality, respectively, while PA reduces mortality and cardiovascular disease. Chronic pain is a major barrier for PA, mainly due to fear of pain exacerbation. Therefore, chronic pain is often presumed to decrease PA, despite contradictory findings in the literature. A systematic review reported a lack of evidence regarding decreased PA in adults with chronic low back pain. Conversely, another systematic review reported decreased PA in older adults with chronic musculoskeletal pain. Importantly, most studies assessed PA using self-reported questionnaires, which are prone to reporting bias.

Objective measurement of PA with accelerometry is nowadays the preferred approach to assess PA. Previous studies using objective assessment of PA mainly focused on specific chronic pain diseases such as fibromyalgia, chronic back pain or osteoarthritis. In these specific groups, chronic pain was generally associated with decreased PA. On the contrary, little is known about the association between chronic pain and PA in the general population. A recent population-based study in the UK found a negative association between the number of painful sites and objectively measured PA, whereas...
no association was found between chronic pain intensity and PA. Similar findings were reported in Japanese older adults by Murata et al. The directionality of the association between chronic pain and PA is also unclear, that is, whether increased chronic pain decreases PA or if increased PA increases (or decreases) chronic pain.

Hence, we assessed the association between chronic pain and PA measured both subjectively and objectively in a population-based cohort. Our hypothesis was that chronic pain intensity and the number of painful sites would be negatively associated with PA.

POPULATION AND METHODS

Study population

The detailed description of recruitment and follow-up procedures of the CoLaus|PsyCoLaus study have been described previously. Briefly, the CoLaus|PsyCoLaus study is a population-based cohort exploring the biological, genetic and environmental determinants of cardiovascular disease and their association with mental disorders. A non-stratified, representative sample of the population of Lausanne, Switzerland, aged 35–75 years was recruited between June 2003 and May 2006. Lausanne is a Swiss city of approximately 145 000 inhabitants as of 2021, with an extensive network of public transport.

The first follow-up was performed between April 2009 and September 2012 and the second one between May 2014 and April 2017. In the second follow-up, participants were asked to fill a questionnaire including items on chronic pain and PA; participants were also invited to have their PA assessed by accelerometry. Hence, for this study, only data of the second follow-up were used. Two sets of analyses were performed for this study. The first one assessed the association between chronic pain and concomitant PA as assessed by the PAFQ. The second one assessed the effect of chronic pain on subsequent PA as assessed by accelerometry.

Chronic pain assessment

Pain was assessed with a self-administered retrospective questionnaire. This questionnaire has been previously applied in a French population-based study and evaluates the presence of daily pain, its duration, intensity, self-reported number of painful sites and neuropathic characteristics (online supplemental annex 1). The neuropathic characteristics of pain were assessed by the pain descriptors of the DN4 score. The DN4 questionnaire showed a high inter-rater reliability, with Kappa values between 0.70 and 0.96. Identification of the cut-off value to identify patients with neuropathic pain was performed using the Youden index. More details can be obtained from Boughassira. No a posteriori corrections of the responses were made, that is, if a participant reported he/she had pain but indicated no painful site, the information was analysed as such. The number of painful sites was categorised as none, 1–2 or 3+

Chronic pain was defined as pain lasting for at least 3 months. Pain intensity was evaluated on a validated Numerical Rating Scale (NRS) ranging from 0=no pain to 10=worst imaginable pain. Participants reported if the pain varied during the last week and indicated the intensity of average pain during the last week. Several studies divided intensity of pain into three categories.

For this study, pain was categorised into none to mild (NRS 0–4), moderate (NRS 5–6) and severe (NRS ≥7) as proposed by a systematic review.

Overall, the following pain types/characteristics were collected: presence of pain (no, yes); chronic pain (no, yes); number of painful sites (0, 1–2, 3+); pain intensity (mild (0–4), moderate (5-6) and severe (7+)) and neuropathic pain (no, yes).

PA assessment

Subjective assessment of PA was performed using the Physical Activity Frequency Questionnaire (PAFQ) (online supplemental annex 2). The PAFQ was validated in the population of Geneva, Switzerland, by comparing the energy expenditure assessed by PAFQ and a heart rate monitor. The heart rate monitor and the PAFQ were highly correlated (r=0.76). The PAFQ is a self-reported questionnaire that assesses the type and duration of 70 different (non-)professional activities and sports during the last 7 days. Participants reported the number of days (0 to 7) and the duration they performed each activity (0–10 hours, with 15 min precision). For each activity/sport the type of PA (ie, sedentary (SED), light, moderate or vigorous) was assessed according to the compendium of physical activities, and the time corresponding to each type of PA was computed. SED activity was defined as <2 metabolic tasks (METs), light PA (LPA) was defined as 2 to <3 METs, and moderate-to-vigorous PA (MVPA) as ≥3 METs. One MET is defined as the energy expended per minute while sitting quietly, equivalent to 3.5 mL of oxygen consumed per kg of body weight per minute for an adult weighing 70 kg.

Objective assessment of PA was performed using a wrist-worn triaxial accelerometer (GENEActiv, Activinsights Ltd, UK, www.activinsights.com). This validated device has been previously used in a large cohort population study. The accelerometers were pre-programmed with a 50 Hz sampling frequency and subsequently attached to the participants’ right wrist. A previous study showed that left or right wrist accelerometer location did not impact PA assessment. After a short training period, participants were requested to wear the device continuously, day and night, for 14 days in their free-living conditions. The data was then analysed using the R-package GGIR V.1.5–9 (http://cran.r-project.org). Non-wear time was defined by the software based on built-in specific criteria. The R-code used to assess PA is provided in online supplemental annex 3. LPA was defined as an acceleration between 40 to 100 mG; moderate PA (MPA) as an acceleration between 100 and 400 mG, and vigorous PA (VPA) as an acceleration above 400 mG. As the time dedicated to...
VPA was small, MPA and VPA were grouped into MVPA as performed in previous studies. As the amount of MVPA depends on the thresholds applied, we ran a sensitivity analysis using the values proposed by White. LPA was defined as an acceleration between 85 and 180 mG; MPA as an acceleration between 181 and 437 mG, and VPA as an acceleration above 437 mG.

Covariates
Professional occupation, smoking status and medications were collected with a self-administered questionnaire. Professional occupation was categorised as professionally active (yes/no). Smoking status was categorised as never, former and current smoker. Medications prescribed or over the counter over the last 6 months were coded using the Anatomical Therapeutic Chemical (ATC) classification. The following painkillers were considered: paracetamol (ATC code: N02BE01), metamizole (N02BP02), anti-inflammatory and antirheumatic products (ATC codes beginning with M01A or M01B), opioids (ATC codes beginning with N02A) and codeine (R05DA04). Salicylates, antidepressors and antiepileptics were not included, as the reason of prescription (ie, pain management or other purpose) was not specified.

Depression was assessed using the CES-D questionnaire (Center for Epidemiologic Studies Depression Scale), and participants were considered as presenting with depression if their score was ≥30.

Weight was measured to the nearest 100 g using a Seca scale (Hamburg, Germany) with participants in light indoor clothes and without shoes. Height was measured to the nearest 5 mm using a Seca height gauge (Hamburg, Germany). Body mass index (BMI) was calculated as weight/height² and categorised as underweight (<18.5 kg/m²), normal (18.5≤BMI <25 kg/m²), overweight (25≤BMI <30 kg/m²) and obese (≥30 kg/m²).

Exclusion criteria
Participants were excluded if they (1) didn’t complete the pain or the PA questionnaires; (2) had missing accelerometry data (defined as >20% of non-wear time or duration <7 days) or (3) had missing covariates data.

Statistical analysis
Statistical analyses were conducted using Stata V15.1 for windows (StataCorp).

Two sets of analyses were performed. The first analyses assessed the association between chronic pain and concomitant PA assessed by the PAFQ. All participants with PAFQ data, irrespective of the accelerometry data, were eligible. The second analyses assessed the effect of chronic pain on subsequent PA assessed by accelerometry. All participants with accelerometry data, irrespective of the PAFQ data, were eligible.

Descriptive results were expressed as number of participants (percentage) for categorical variables and average ±SD or median (IQR) for continuous variables. Bivariate analyses were performed using chi-square for categorical variables and Student’s t-test, analysis of variance or Kruskall-Wallis for continuous variables. Multivariable analysis was performed using analysis of variance for continuous variables, and results were expressed as multivariable-adjusted means±SE. Statistical significance was assessed for a two-sided test with p<0.05.

Patient and public involvement
Patients and the public were not involved in the design or planning of the study.

RESULTS
Association between chronic pain and concomitant, subjectively assessed PA
Of the initial 4881 participants, 2598 (53.2%) were included in the analysis between chronic pain and concomitant, subjectively assessed PA. Exclusion criteria are presented in online supplemental figure 1 and the characteristics of included and excluded participants are summarised in online supplemental table 1. Included participants were younger, more frequently non-smokers and had a lower BMI. Of the 2598 included participants, 2592 (97%) had data for depression. Included participants presented less frequently with depression, although a considerable number of excluded participants did not present data for depression (online supplemental table 1).

The characteristics of the participants according to the number of painful sites are summarised in online supplemental table 2. Participants with a higher number of painful sites were older, more frequently women, had a higher BMI, received a higher number of painkillers and presented more frequently with depression.

The bivariate and multivariate associations between chronic pain and concomitant, subjectively assessed PA are summarised in online supplemental table 3 and table 1, respectively. On bivariate analysis, a higher number of painful sites was negatively associated with depression and positively associated with LPA; higher pain intensity was negatively associated with MVPa (online supplemental table 3). On multivariable analysis, a higher number of painful sites was negatively associated with SED, while no association was found between pain intensity categories and PA levels (table 1). Similar findings were obtained after adjustment on depressive status (online supplemental table 4).

Association between chronic pain and subsequent, objectively assessed PA
Of the initial 4881 participants, 2205 (45.2%) were included. Exclusion criteria are presented in online supplemental figure 2 and the characteristics of included and excluded participants are summarised in online supplemental table 5. Included participants were younger, more frequently non-smokers and taking antidepressants. Of the 2205 included participants, 2102 (95%) had data for depression. No difference was found in the prevalence of depression between included and excluded participants.
although a considerable number of excluded participants did not have data for depression (online supplemental table 5).

The characteristics of the participants according to the number of painful sites are summarised in online supplemental table 6. Participants with a higher number of painful sites were more frequently women, had a higher BMI, had a higher number of painkillers and presented more frequently with depression.

The bivariate and multivariate associations between chronic pain and subsequent, objectively assessed PA are summarised in online supplemental table 7 and table 2, respectively. On bivariate analysis, everyday pain and number of painful sites were negatively associated with MVPA (online supplemental table 7). After multivariable adjustment, the association between number of painful sites and MVPA was no longer significant, and no association between pain intensity categories and the different types of PA was found (table 2). Further adjusting for depression led to similar findings, although a higher engagement in LPA among participants with neuropathic pain was found (online supplemental table 8).

A sensitivity analysis using higher thresholds to define MVPA led to considerable smaller amounts of MVPA performed, but no changes regarding the associations between pain and PA levels (online supplemental table 9).

### DISCUSSION

A few studies have assessed the association between chronic pain and PA at the population level. Contrary to our initial hypothesis, our results suggest that chronic pain is associated neither with concomitant nor with prospective PA in a sample of community-dwelling people.

#### Association between chronic pain and concomitant, subjectively assessed PA

Self-reported SED was negatively associated with the number of painful sites, meaning that people having...
Table 2  Multivariable-adjusted associations between chronic pain markers and prospective, objectively assessed physical activity the following 2 weeks, CoLaus|PsyCoLaus study, Lausanne, Switzerland, May 2014 to April 2017

|                         | N     | Sedentary | Light physical activity | Moderate-to-vigorous physical activity |
|-------------------------|-------|-----------|-------------------------|----------------------------------------|
|                         |       | Min/day   | % time                  | Min/day                                | % time                                |
| **Everyday pain**       |       |           |                         |                                        |                                        |
| No                      | 1038  | 594±2     | 68.4±0.3                | 179±2                                  | 20.4±0.2                              | 98±2                                  | 11.2±0.2                             |
| Yes                     | 1167  | 594±2     | 68.7±0.3                | 182±2                                  | 20.4±0.2                              | 95±1                                  | 10.9±0.2                             |
| **P value**             |       | 0.944     | 0.476                   | 0.744                                  | 0.999                                  | 0.208                                 | 0.166                                |
| **Chronic pain (≥3 months)** |       |           |                         |                                        |                                        |
| No                      | 151   | 602±6     | 69.6±0.7                | 176±4                                  | 20.2±0.4                              | 90±4                                  | 10.2±0.4                             |
| Yes                     | 927   | 593±2     | 68.7±0.3                | 180±2                                  | 20.6±0.2                              | 94±2                                  | 10.7±0.2                             |
| **P value**             |       | 0.219     | 0.255                   | 0.457                                  | 0.371                                  | 0.332                                 | 0.283                                |
| **No of painful sites** |       |           |                         |                                        |                                        |
| 0                       | 1158  | 595±2     | 68.6±0.3                | 178±2                                  | 20.3±0.2                              | 97±1                                  | 11.1±0.2                             |
| 1–2                     | 504   | 594±3     | 68.7±0.4                | 178±2                                  | 20.4±0.2                              | 96±2                                  | 10.9±0.2                             |
| 3+                      | 543   | 590±3     | 68.4±0.4                | 180±2                                  | 20.6±0.2                              | 96±2                                  | 11.0±0.2                             |
| **P value for trend**   |       | 0.185     | 0.690                   | 0.598                                  | 0.283                                  | 0.630                                 | 0.614                                |
| **Pain intensity**      |       |           |                         |                                        |                                        |
| Mild (0–4)              | 577   | 597±3     | 69.2±0.4                | 177±2                                  | 20.4±0.2                              | 91±2                                  | 10.5±0.2                             |
| Moderate (5–6)          | 222   | 586±5     | 68.0±0.6                | 182±3                                  | 20.9±0.3                              | 98±3                                  | 11.2±0.3                             |
| Severe (7–10)           | 83    | 593±8     | 68.4±1.0                | 185±5                                  | 21.2±0.6                              | 92±5                                  | 10.4±0.6                             |
| **P value for trend**   |       | 0.635     | 0.479                   | 0.169                                  | 0.179                                  | 0.951                                 | 0.938                                |
| **Neuropathic pain**    |       |           |                         |                                        |                                        |
| No                      | 432   | 597±3     | 69.4±0.4                | 176±2                                  | 20.3±0.2                              | 90±2                                  | 10.4±0.2                             |
| Yes                     | 61    | 586±9     | 67.5±1.1                | 188±6                                  | 21.4±0.7                              | 98±6                                  | 11.7±0.6                             |
| **P value**             |       | 0.275     | 0.126                   | 0.096                                  | 0.099                                  | 0.208                                 | 0.311                                |

Results are expressed as multivariable-adjusted mean±SE. Between-group comparisons performed for each pain characteristic using analysis of variance, adjusting for age (continuous), gender (man, woman), smoking (never, former, current), body mass index categories (normal, overweight, obese), presence of pain killers (yes, no) and currently working (yes, no).

more painful sites were less sedentary. A possible explanation is that the location of the painful sites is more important than their total number; for instance, painful sites in the lower limbs might reduce PA more strongly than painful sites in the upper limbs. Overall, our results suggest that the number of painful sites has little impact on PA or that taken globally, PA is not a good marker for the impact of pain on daily-life and more refined activity-analysis should be performed.

No association was found between pain intensity and self-reported PA. Our findings are in agreement with a previous Dutch study, which found no association between pain intensity and self-reported PA in patients with chronic low back pain. The investigated population was younger, aged 18–65 years old, compared with our study (mean age 60.5 years). Furthermore, pain intensity was evaluated with a momentary pain intensity assessment (‘Right now, I am in pain’) and a seven point Likert scale. Conversely, our results contradict a previous Swedish study conducted by Larsson, where average pain intensity the last 7 days was negatively associated with self-reported PA. However, the Swedish authors used a different pain intensity scale (six point Likert scale ranging from 0=no pain at all to 6=tremendous amount of pain), a different PA assessment (one question, answer with six levels) and the population investigated was older (mean age 74.4 vs 60.5 years in our study). Overall, our results suggest that the association between pain intensity and PA might not exist or might be dependent on the methodology used to assess pain and PA. Pain might influence the type of activity more than its intensity.

The NRS is a well-validated pain intensity scale and is recommended by the Initiative on Methods, Measurement and Pain Assessment in Clinical Trials (IMMPACT). To decrease variability between studies, the IMMPACT recommendations suggest using a specific format for the instructions regarding the description of the 11-point scale. Furthermore, the IMMPACT recommendations suggest evaluating the absolute changes in pain intensity and the percentages of patients obtaining reductions in pain intensity of at least 30% from baseline. Therefore, we suggest considering these methodology recommendations in future studies.
Association between chronic pain and subsequent, objectively assessed PA
No significant association between chronic pain and subsequent objectively assessed PA was found after multivariable analyses. This finding is in agreement with a Danish study conducted in 2019 in healthcare workers, where no association was found between objectively measured occupational PA and multisite pain (≥2 sites). Similarly, a study conducted by Kratz et al. reported persistence of PA despite a higher number of painful sites due to pain acceptance. Conversely, a Japanese study and a UK study found a negative association between the number of chronic musculoskeletal pain sites and MVPA. Possible explanations for these inconsistent findings could be the inclusion of older adults (75.3 vs 61.7 years in our study) or different pain perceptions related to ethnicity in the Japanese study, and a higher prevalence of women (62% vs 53%) and of pain in ≥4 sites (69% vs 16%) in the UK study. Our sample was also not restricted to musculoskeletal pain. Finally, in the UK study, the decrease in MVPA was less than 5 minutes/day, which might not be clinically relevant. Overall, our results suggest that there is no association between the number of painful sites and PA.

No association was found between chronic pain intensity and PA. This finding is in agreement with studies conducted in the Netherlands and in Japan. A possible explanation is that participants with chronic pain remain physically active due to decreased pain sensitivity with regular PA. Furthermore, healthcare professionals advocate to remain active despite pain. Interestingly, a study reported that high pain intensity does not impact quantitative PA metrics, but impacts the temporal organisation of PA patterns, combining type, intensity and duration of PA. For instance, high pain intensity may increase the duration of rest periods and decrease the duration of PA periods, or increase PA in the mornings and decrease PA in the evenings.

Recommendations for future research
Future research assessing the relationships between pain and PA could use ‘real-time’ pain assessment using methods such as ecological momentary assessment. The IMMPACT recommendations should be considered when designing future studies assessing chronic pain and PA. The following outcome domains should be considered: pain, physical functioning, emotional functioning, participant ratings of improvement and satisfaction with treatment, symptoms and adverse events, participant disposition.

Strengths and limitations
Our study assessed the association between chronic pain and PA in a large, community-dwelling sample, while previous studies mainly evaluated this association in patients with a specific disease. Moreover, our study assessed the association between chronic pain and both subjectively and objectively measured PA, whereas previous studies mainly used subjectively assessed PA. Also, we could assess the associations between chronic pain and PA both at the cross-sectional (subjective) and the prospective (objective) level. Finally, the sample size was relatively large, providing adequate power to detect clinically meaningful associations. In comparison, the two previous studies exploring this association in the general population included 267 and 9856 participants.

This study also has several limitations. First, our sample was composed of mostly Caucasian people aged 45–85 years living in the city of Lausanne, Switzerland. Hence, its generalisability to populations differing in age, ethnicity and/or culture remains to be assessed. Still, previous studies on the effects of ethnicity on pain are inconsistent; one study reported that ethnicity influences pain perception, while another failed to find such an association.

Second, we had to exclude participants with missing pain, PA or covariates data. As excluded participants were older and had a higher BMI, this might have led to an underestimation of chronic pain. However, older age and higher BMI are also associated with decreased PA; therefore, the associations between chronic pain and PA would presumably remain the same. Third, the subjective assessment of the association between chronic pain and PA may be influenced by source bias. Therefore, we included an objective assessment of the association between chronic pain and PA, using accelerometry. To note, no association was found between chronic pain and PA measured both subjectively and objectively. Finally, the quantification of stationary behaviour and light, MPA and VPA relies on specific thresholds, and the software package used. Despite several proposed thresholds in the literature based on calibration studies there is no agreement regarding which thresholds to apply for each specific software. Still, using two different thresholds led to similar findings, suggesting that the absence of association between pain and PA does not depend on the threshold used to define MVPA.

CONCLUSION
In this Swiss population-based sample, no association was found between chronic pain and PA. Hence, in the general population, chronic pain does not preclude being physically active.

Twitter Pedro Marques-Vidal @PMarquesVidal

Contributors OA, PM-V and PV designed the study. OA interpreted the results and wrote the manuscript. PM-V performed the statistical analyses, wrote the statistical analysis part, and revised the manuscript. PV and MRS reviewed the manuscript for important intellectual content. All authors approved the final version of the manuscript. PV had full access to the data and is the guarantor of the study.

Funding This work was supported by research grants from GlaxoSmithKline, the Faculty of Biology and Medicine of Lausanne, and the Swiss National Science Foundation (grant numbers: 33CSCO-122661, 33CS30-139468, 33CS30-148401 and 33CS30_17735/1).

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by Ethics Commission of Canton Vaud and approved the baseline Colaust study (reference number: 2020-001166).

Aebischer O, et al. BMJ Open 2022;12:e057288. doi:10.1136/bmjopen-2021-057288

6

Aebischer O, et al. BMJ Open 2022;12:e057288. doi:10.1136/bmjopen-2021-057288

Open access

BMJ Open: first published as 10.1136/bmjopen-2021-057288 on 29 July 2022. Downloaded from http://bmjopen.bmj.com/ on December 30, 2022 by guest. Protected by copyright.
16(03). The approval was renewed for the first (reference 33/09) and second follow-up (reference 26/14). Participants gave informed consent to participate in the study before taking part.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available on reasonable request. Due to the sensitivity of the data and the lack of consent for online posting, individual data cannot be made accessible. Only metadata will be made available in digital repositories. Metadata requests can also be performed via the study website www. coalaus-psycolaus.ch.

**Supplemental material** This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

**Open access** This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

**ORCID iDs**
Oriane Aebischer http://orcid.org/0000-0003-3193-7093
Marc René Suter http://orcid.org/0000-0002-4653-0512
Peter Vollenweider http://orcid.org/0000-0002-0765-896X
Pedro Marques-Vidal http://orcid.org/0000-0002-4548-8500

**REFERENCES**
1. Torrance N, Elliott AM, Lee AJ, et al. Severe chronic pain is associated with increased 10 year mortality. A cohort record linkage study. Eur J Pain 2016;1:380–6.
2. Tesarz J, Eich W, Baumeister D, et al. Widespread pain is a risk factor for cardiovascular mortality: results from the Framingham heart study. Eur Heart J 2019;40:1609–17.
3. Kim Y, Umeda M. Chronic pain, physical activity, and all-cause mortality in the US adults: the NHANES 1999–2004 follow-up study. Am J Health Promot 2019;33:1182–6.
4. Warburton DER, Nicol CW, Bredin SSD. Health benefits of physical activity: the evidence. CMAJ 2006;174:801–9.
5. Ho A, Ashie MC, Delongis A, et al. Gender differences in pain-physical activity relationships among older adults: lessons learned from daily life approaches. Pain Res Manag 2016;2016:1–9.
6. Damsgard E, Thrane G, Anke A, et al. Activity-Related pain in patients with chronic musculoskeletal disorders. Disabil Rehabil 2010;32:1428–37.
7. McPhail SM, Schippers M, Marshall AL, et al. Perceived barriers and facilitators to increasing physical activity among people with musculoskeletal disorders: a qualitative investigation to inform intervention development. Clin Interv Aging 2014;9:2113–22.
8. Vater K, Dousal T, Patel R, et al. Experiences, barriers, and facilitators of participating in physical activity and exercise in adults living with chronic pain: a qualitative study, Disabil Rehabil 2021;43:1–9.
9. Griffin DW, Harmon DC, Kennedy NM. Do patients with chronic low back pain have an altered level and/or pattern of physical activity compared to healthy individuals? A systematic review of the literature. Physiotherapy 2012;98:13–23.
10. Stubbs B, Binnekade TT, Soudry A, et al. Are older adults with chronic musculoskeletal pain less active than older adults without pain? A systematic review and meta-analysis. Pain Med 2013;14:1316–31.
11. Lin C-WC, McAuley JH, Macedo L, et al. Relationship between physical activity and disability in low back pain: a systematic review and meta-analysis. Pain 2011;152:607–13.
12. Stubbs B, Patchay S, Soudry A, et al. The avoidance of activities due to fear of falling contributes to sedentary behavior among community-dwelling older adults with chronic musculoskeletal pain: a multivariate observational study. Pain Med 2014;15:1861–71.
13. Patel KV, Dansie EJ, Turk DC. Impact of chronic musculoskeletal pain on objectively measured daily physical activity: a review of current findings. Pain Manag 2013;3:467–74.
14. Dansie EJ, Turk DC, Martin KR, et al. Association of chronic widespread pain with objectively measured physical activity in adults: findings from the National health and nutrition examination survey. J Pain 2014;15:507–15.
15. van den Berg-Emons RJ, Schasfoort FC, de Vos LA, et al. Impact of chronic pain on everyday physical activity, Eur J Pain 2007;11:587–93.
16. Pan F, Byrne KS, Ramakrishnan R, et al. Association between musculoskeletal pain at multiple sites and objectively measured physical activity and work capacity: results from UK Biobank study. J Sci Med Sport 2019;22:444–9.
17. Murata S, Doi T, Sawa R, et al. Association between objectively measured physical activity and the number of chronic musculoskeletal pain sites in community-dwelling older adults. Pain Med 2019;20:717–24.
18. Firman M, Mayor V, Vidal PM, et al. The CoLaus study: a population-based study to investigate the epidemiology and genetic determinants of cardiovascular risk factors and metabolic syndrome. BMC Cardiovasc Disord 2008;8:6.
19. Bouhassira D, Lantéri-Minet M, Attal N, et al. Prevalence of chronic pain with neuropathic characteristics in the general population. Pain 2008;136:380–7.
20. Bouhassira D, Attal N, Alchaar H, et al. Comparison of pain syndromes associated with nervous or somatic lesions and development of a new neuropathic pain diagnostic questionnaire (DN4). Pain 2005;116:28–36.
21. Oldenmenger WH, de Raaf PJ, de Klerk C, et al. Cut points on 0–10 numeric rating scales for symptoms included in the Edmonton symptom assessment scale in cancer patients: a systematic review. J Pain Symptom Manage 2013;45:1083–93.
22. Esliger DW, Collett B, Venturafrida V, et al. Survey of chronic pain in Europe: prevalence, impact on daily life, and treatment. Eur J Pain 2006;10:287–333.
23. Bernstein M, Sloutskis D, Kumanisky S, et al. Data-Based approach for developing a physical activity frequency questionnaire. Am J Epidemiol 1999;147:147–54.
24. Ainsworth BE, Haskell WL, Leon AS, et al. Compendium of physical activities: classification of energy costs of human physical activities. Med Sci Sports Exerc 1993;25:71–80.
25. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and Met intensities. Med Sci Sports Exerc 2000;32:5498–516.
26. Verhoog S, Gubelmann C, Guessed S, et al. Comparison of the physical activity frequency questionnaire (PAFQ) with accelerometry in a middle-aged and elderly population: the CoLaus study. Maturitas 2019;129:88–75.
27. Esliger DW, Rowlands AV, Hurst TL, et al. Validation of the GENEA Accelerometer. Med Sci Sports Exerc 2011;43:1085–93.
28. Cassidy S, Fuller H, Chau J, et al. Accelerometer-derived physical activity in those with cardio-metabolic disease compared to healthy adults: a UK Biobank study of 52,556 participants. Acta Diabetol 2018;55:979–9.
29. White T, Westgate K, Wareham NJ, et al. Estimation of physical activity energy expenditure during free-living from wrist accelerometry in UK adults. PLoS One 2016;11:e0167472.
30. van Hees VT, Fang Z, Langford J, et al. Autocalibration of accelerometer data for free-living physical activity assessment using local gravity and temperature: an evaluation on four continents. J Appl Physiol 2014;117:738–44.
31. Migueles JH, Rowlands AV, Huber F, et al. Gqgr: a research community–driven open source R package for generating physical activity and sleep outcomes from multi-day RAW accelerometer data. J Meas Phys Behav 2019;2:158–68.
32. Gubelmann C, Heinzer R, Habu-Rubio J, et al. Physical activity is associated with higher sleep efficiency in the general population: the CoLaus study. Sleep 2018;41:zsy070.
33. Huijnen IPJ, Verbunt JA, Peters ML, et al. Differences in activity-related behaviour among patients with chronic low back pain. Eur J Pain 2011;15:748–55.
34. Larsson C, Ekwall Hansson E, Sundquist K, et al. Impact of pain characteristics and fear-avoidance beliefs on physical activity levels among older adults with chronic pain: a population-based, longitudinal study. BMC Geriatr 2016;16:90.
35. Dworkin RH, Turk DC, Farrar JT, et al. Core outcome measures for chronic pain clinical trials: IMPACT recommendations. Pain 2005;113:9–19.
36. Neupane S, Karstad K, Hallman DM, et al. Objectively measured versus self-reported occupational physical activity and multisite musculoskeletal pain: a prospective follow-up study at 20 nursing homes in Denmark. Int Arch Occup Environ Health 2020;93:381–9.
37 Kratz AL, Ehde DM, Bombardier CH, et al. Pain acceptance decouples the momentary associations between pain, pain interference, and physical activity in the daily lives of people with chronic pain and spinal cord injury. *J Pain* 2017;18:319–31.

38 Krupič F, Čustović S, Jašarević M, et al. Ethnic differences in the perception of pain: a systematic review of qualitative and quantitative research. *Med Glas* 2019;16:108–14.

39 Sluka KA, Frey-Law L, Hoeger Bement M. Exercise-Induced pain and analgesia? underlying mechanisms and clinical translation. *Pain* 2018;159 Suppl 1:S91–7.

40 Paraschiv-Ionescu A, Perruchoud C, Buchser E, et al. Barcoding human physical activity to assess chronic pain conditions. *PLoS One* 2012;7:e32239.

41 Paraschiv-Ionescu A, Buchser E, Aminian K. Unraveling dynamics of human physical activity patterns in chronic pain conditions. *Sci Rep* 2013;3:2019.

42 Perruchoud C, Buchser E, Johanek LM, et al. Assessment of physical activity of patients with chronic pain. *Neuromodulation* 2014;17 Suppl 1:42–7.

43 May M, Junghaenel DU, Ono M, et al. Ecological momentary assessment methodology in chronic pain research: a systematic review. *J Pain* 2018;19:699–716.

44 Ramer L, Richardson JL, Cohen MZ, et al. Multimeasure pain assessment in an ethnically diverse group of patients with cancer. *J Transcult Nurs* 1999;10:94–101.

45 McPhee JS, French DP, Jackson D, et al. Physical activity in older age: perspectives for healthy ageing and frailty. *Biogerontology* 2016;17:567–80.

46 Maher CA, Mire E, Harrington DM, et al. The independent and combined associations of physical activity and sedentary behavior with obesity in adults: NHANES 2003-06. *Obesity* 2013;21:E730–7.

47 Matthew CE. Calibration of accelerometer output for adults. *Med Sci Sports Exerc* 2005;37:S512–22.