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Association between physical activity and musculoskeletal pain: an analysis of international data from the ASAP survey

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ABSTRACT

Objective To explore the association of physical activity (PA) with musculoskeletal pain (MSK pain).

Design Cross-sectional study

Setting 14 countries (Argentina, Australia, Austria, Brazil, Chile, France, Germany, Italy, the Netherlands, Singapore, South Africa, Spain, Switzerland and the USA).

Participants Individuals aged 18 or older.

Primary and secondary outcome measures PA volumes were assessed with an adapted version of the Nordic Physical Activity Questionnaire-short. Prevalence of MSK pain was captured by means of a 20-item checklist of body locations. Based on the WHO recommendation on PA, participants were classified as non-compliers (0–150 min/week), compliers (150–300 min/week), double compliers (300–450 min/week), triple compliers (450–600 min/week), quadruple compliers (600–750 min/week), quintuple compliers (750–900 min/week) and top compliers (more than 900 min/week). Multivariate logistic regression was used to obtain adjusted ORs of the association between PA and MSK pain for each body location, correcting for age, sex, employment status and depression risk.

Results A total of 13 741 participants completed the survey. Compared with non-compliers, compliers had smaller odds of MSK pain in one location (thoracic pain, OR 0.77, 95% CI 0.64 to 0.93). Double compliance was associated with reduced pain occurrence in six locations (elbow, OR 0.70, 95% CI 0.50 to 0.98; forearm, OR 0.63, 95% CI 0.40 to 0.99; wrist, OR 0.74, 95% CI 0.57 to 0.98; hand, OR 0.57, 95% CI 0.40 to 0.79; fingers, OR 0.72, 95% CI 0.52 to 0.99; abdomen, OR 0.61, 95% CI 0.41 to 0.91). Triple to top compliance was also linked with lower odds of MSK pain (five locations in triple compliance, three in quadruple compliance, two in quintuple compliance, three in top compliance), but, at the same time, presented increased odds of MSK pain in some of the other locations.

Conclusion A dose of 300–450 min WHO-equivalent PA/week was associated with lower odds of MSK pain in six body locations. On the other hand, excessive doses of PA were associated with higher odds of pain in certain body locations.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This is the first large-scale analysis of associations between musculoskeletal pain (MSK pain) and physical activity (PA) considering multiple anatomical locations.
⇒ Large sample size enabled to investigate the associations between different degrees of compliance to PA recommended by WHO and MSK pain.
⇒ Administration of the survey in 14 countries allowed participation of diverse populations.
⇒ Self-reported data may be subject to recall bias.
⇒ Cross-sectional observational design prohibits causal inference.

INTRODUCTION

Musculoskeletal pain (MSK pain) is a common condition that can have negative physical, psychological and social impacts.[1] A summary of previous epidemiological studies conducted with diverse techniques and populations revealed that MSK pain affects between 13.5% and 47% of the general population, with prevalence higher in women and increasing strongly with age.[2] Musculoskeletal conditions contribute to disability, especially in older age groups.[2] It has been reported that disability-adjusted life-years, which reflect the years of life lost due to premature mortality and years of life lived with disability, increased by 62% between 1990 and 2016 around the world with 20% surge during the 10-year interval from 2006 to 2016.[3] Most of the increased burden has derived from disability due to increased ageing population affected by MSK conditions, and the burden of MSK disorders is expected to increase even more in the future.[4]

Achieving sufficient physical activity (PA) is associated with a variety of positive health outcomes such as substantial risk reduction in all-cause mortality[5] as well as multiple chronic diseases including type 2 diabetes and metabolic syndrome,[6] cancer[6] and cardiovascular disease.[7] In the light of these positive impacts, WHO recommends 150–300 min of moderate-intensity PA, or 75–150 min of vigorous-intensity PA or aerobic PA with some combination of moderate and vigorous intensities.[8] PA is also considered one of the most important strategies to prevent and manage MSK pain.[9] However, compared with the available evidence on the association of PA with non-communicable disease, there seems to be a fewer number of studies on the topic of PA and MSK pain. Furthermore, it is still less clear whether the amounts recommended by WHO are sufficient to elicit benefits in terms of addressing MSK pain. The few available studies examining the relation of regular PA and MSK pain tended to focus on influence of PA for specific body locations or specific diagnoses such as low back pain, neck pain or osteoarthritis and found inconsistent results.[10] Other studies have evaluated the associations between PA and pain in occupational settings such as among physical therapists or teaching staff.[11 12] Particularly, the interplay between the volume of PA and MSK pain within the general population has been less explored.

The purpose of this study was to explore the association of total PA with presence of MSK pain in a variety of anatomical locations including both upper and lower extremities. We hypothesised that greater time spent in PA than WHO recommendation would be associated with the absence of MSK pain in more body regions, but that excess time performing PA might be associated with the presence of MSK pain in more body regions.

METHODS

Study design

This article presents an explorative analysis of prepandemic baseline data on PA and MSK pain assessed during the ASAP (Activity and Health during the SARS-CoV-2 Pandemic) survey. The survey was administered with results collected between 3 April 2020 and 9 May 2020, including participants from 14 countries (Argentina, Australia, Austria, Brazil, Chile, France, Germany, Italy, the Netherlands, Singapore, South Africa, Spain, Switzerland and the USA).[13–16]

Participants

Eligibility for participation in the ASAP survey was limited to individuals aged 18 or older living in participating countries. Recruitment was performed online using promotion by health-related organisations, mailing lists and social media advertising (eg, Facebook, Instagram, Twitter).

Questionnaire

To capture PA, the ASAP survey incorporated an adapted version of the Nordic Physical Activity Questionnaire-short (NPAQ-short). The instrument retrospectively assessed the amounts of moderate and combined moderate and vigorous activities (min/week) during leisure and occupational time. Moderate activities were defined as those that increase heart rate or breathing, and vigorous activities were defined as those that make heart racing, sweating and shortness of breath. The questionnaire asked how much time participants spent in total on both moderate and vigorous PA on a typical week, and the time spent in all activities with a minimal duration of 10 min was asked to be added and entered in the form. The NPAQ-short has been shown to be reliable (test–retest reliability: r=0.80–0.82) and valid for observing compliance with the WHO recommendations on PA.[17] The questionnaire was available in seven different languages (Dutch, English, German, French, Italian, Brazilian-Portuguese, Spanish), and clarity and comprehensibility were validated by native speakers through forward and backward translation.

Prevalence of MSK pain was captured by means of binary responses (yes/no) to an adapted 20-item checklist from a consensus statement on epidemiological injury reporting.[18] Body locations were categorised as follows: neck/cervical spine, shoulder, upper arm, elbow, forearm, wrist, hand, fingers, thoracic spine, ribs, lower back, abdomen, pelvis/gluteal, hip, groin, thigh, knee, lower leg, ankle/Achilles tendon and foot/toe.

The English version of the ASAP survey can be found in online supplemental file 1).

Data processing and statistical analysis

Self-reported PA was categorised as multiples of compliance with WHO guidelines which recommend 150–300 min/week of moderate activity, 75–150 min/week of vigorous activity or any adequate combination of both.[8] We used the formula *(minutes of moderate-to-vigorous PA – minutes of vigorous PA) + minutes of vigorous PA × 2* to classify participants as non-compliers (0–150 min/week), compliers (150–300 min/week), double compliers (300–450 min/week), triple compliers (450–600 min/week), quadruple compliers (600–750 min/week), quintuple compliers (750–900 min/week) and top compliers (more than 900 min/week). In addition to the assessment of PA, participants were asked where they worked in multiple choices which also included a 'no employment' option, and the answers to this question were used to categorise participants into being employed or not employed for our analysis. Also, the WHO Well-Being Index was used to capture depression risk as validated by previous research.[19]

For each body region, univariate binary logistic regression was conducted to calculate the unadjusted OR of the association between pain (dependent variable: yes/no) and PA. In a similar way, univariate binary logistic regression was then used to identify associations of pain (dependent variable) and potential confounding variables (sex, age, employment status, depression risk). Finally, multivariate binary logistic regression was performed including these confounding variables (if relevant) to obtain the adjusted ORs and 95% CI of the association between the volume of PA and pain (dependent variable). As participants may have a strongly varying number of pain locations and as the impact of pain on the individual may vary with the number of affected body regions, additional analyses, using the same procedures as described above (binary logistic regression corrected for confounders), were performed to obtain adjusted OR for pain in only one, at least 3, 5, or 10 body locations.

All data analyses were conducted using SPSS V.22 (SPSS), and the significance level was set to α=0.05.

Patient and public involvement

Members of the target population without medical background were involved in the designing phase of the ASAP questionnaire. The questionnaire was face validated for each language with five non-academic individuals. Feedback on comprehension and clarity of the wording was used.

RESULTS

Valid datasets were identified for 13 741 participants (38±15 years, minimum 18 and maximum 100, 59% females). The demographic data are summarised in table 1. A total of 2604 individuals did not meet the WHO recommendation of PA while n=2735 belonged to 150–300 min group, n=1957 to 300–450 min group, n=1749 to 450–600 min group, n=1066 to 600–750 min group, n=849 to 750–900 min group and n=2781 to 900+ min group. Comprehensive results are summarised in tables 2 and 3.

Compared with inactive individuals, simple guideline compliance was associated with lower odds of suffering from MSK pain in one body location (thoracic pain, OR 0.77, 95% CI 0.64 to 0.93, table 1). Double compliance was associated with lower odds of suffering from MSK pain in six locations (elbow, OR 0.70, 95% CI 0.50 to 0.98; forearm, OR 0.63, 95% CI 0.40 to 0.99; wrist, OR 0.74, 95% CI 0.7 to 0.98; hand, OR 0.57, 95% CI 0.40 to 0.79; fingers, OR 0.72, 95% CI 0.52 to 0.99; abdomen, OR 0.61, 95% CI 0.41 to 0.91). Although higher amounts of PA were associated with lower odds of suffering from MSK pain in variable numbers of locations (five body locations in triple compliance, three in quadruple compliance, two in quintuple compliance and three in top compliance), they were also associated with higher odds of suffering from MSK pain in other locations. Specifically, triple compliance was associated with presence of MSK pain in thigh (OR 1.41, 95% CI 1.03 to 1.92), knee (OR 1.25, 95% CI 1.06 to 1.50) and ankle/Achilles tendon (OR 1.47, 95% CI 1.14 to 1.88). Quadruple compliance increased pain locations to four, quintuple compliance to six and top compliance to seven.

Triple compliance was associated with lower odds to have a total of 5 or more (OR 0.75, 95% CI 0.60 to 0.95) or 10 or more (OR 0.36, 95% CI 0.19 to 0.68) pain locations, and quadruple compliance was associated with lower odds to have 5 or more pain locations (OR 0.73, 95% CI 0.57 to 0.93). However, quintuple and top compliances were associated with higher odds of having a minimum one pain location (OR 1.28, 95% CI 1.10 to 1.51 and 1.30, 95% CI 1.16 to 1.45, respectively).

Table 1 Demographic data of the participants by countries

Country	ARG	AUS	AUT	BRA	CHE	CHL	DEU	ESP	FRA	ITA	NLD	SGP	USA	ZAF	Others	Total
Sex (M/F)	429/494	56/248	192/546	620/948	115/212	471/766	696/1356	310/277	1200/1046	348/453	50/129	437/434	364/711	236/293	108/122	5632/8035
Age (SD)	37.1 (15.4)	41.6 (14.1)	27.3 (9.6)	34.2 (10.6)	37.3 (11.5)	31.5 (13.6)	40.4 (16.3)	43.0 (13.4)	43.3 (16.9)	38.5 (15.3)	47.5 (14.0)	40.1 (12.1)	43.1 (14.0)	32.4 (14.3)	40.0 (13.5)	38.3 (15.1)
WHO-5 (SD)	54.3 (17.8)	50.1 (14.8)	55.0 (16.5)	53.0 (16.0)	50.4 (15.2)	54.7 (18.2)	52.9 (17.0)	49.2 (15.8)	48.3 (14.8)	56.3 (17.3)	49.0 (14.7)	52.2 (17.6)	49.4 (14.9)	52.2 (21.1)	51.2 (17.2)	52.0 (16.8)
Employment (Yes, %)	61.9	86.8	62.7	78.8	96.0	59.2	73.2	79.8	69.9	65.9%	77.1	88.8	84.1	53.7	85.0	72.8
MVPA (SD)	488.7 (596.2)	352.3 (340.0)	384.6 (408.7)	396.4 (454.9)	379.0 (458.1)	385.7 (518.3)	438.6 (481.3)	493.2 (617.0)	527.9 (516.0)	566.2 (635.3)	506.5 (420.5)	376.5 (445.7)	401.0 (348.0)	310.6 (455.8)	437.8 (529.7)	439.5 (498.7)
VPA (SD)	218.7 (338.0)	121.3 (152.4)	141.4 (206.5)	202.0 (305.7)	130.6 (152.6)	153.9 (287.9)	146.9 (226.5)	188.4 (295.2)	234.7 (343.3)	247.2 (350.1)	200.2 (225.7)	171.0 (302.4)	195.9 (230.0)	144.1 (272.7)	203 (275.6)	186.4 (288.8)

AGR, Argentina; AUS, Australia; AUT, Austria; BRA, Brazil; CHE, Switzerland; CHL, Chile; DEU, Germany; ESP, Spain; F, female; FRA, France; M, male; MVPA, moderate to vigorous physical activity; NLD, Netherlands; SGP, Singapore; VPA, vigorous physical activity; WHO-5, WHO Well-Being Index; ZAF, South Africa.

Table 2 Association of PA with MSK pain by anatomical locations

Location of MSK pain	Dose of WHO guideline-based PA											
	150–300 min		300–450 min		450–600 min		600–750 min		750–900 min		900+ min	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Neck/cervical	0.89 (0.79 to 1.01)	0.99 (0.87 to 1.12)	0.76 (0.67 to 0.88)	0.89 (0.77 to 1.03)	0.66 (0.57 to 0.76)	**0.78 (0.67 to 0.91)**	0.62 (0.52 to 0.74)	**0.75 (0.62 to 0.90)**	0.63 (0.52 to 0.77)	**0.82 (0.67 to 1.00)**	0.59 (0.52 to 0.67)	**0.78 (0.68 to 0.89)**
Shoulder	0.87 (0.75 to 1.00)	0.92 (0.79 to 1.06)	0.87 (0.74 to 1.02)	0.94 (0.79 to 1.10)	0.83 (0.71 to 0.99)	0.93 (0.79 to 1.11)	0.80 (0.66 to 0.98)	0.88 (0.72 to 1.08)	1.10 (0.90 to 1.34)	**1.27 (1.04 to 1.56)**	0.98 (0.85 to 1.13)	**1.16 (1.00 to 1.34)**
Upper arm	0.77 (0.60 to 1.00)	0.98 (0.76 to 1.27)	0.60 (0.44 to 0.81)	0.81 (0.60 to 1.11)	0.56 (0.41 to 0.77)	0.76 (0.54 to 1.05)	0.62 (0.42 to 0.89)	0.81 (0.55 to 1.19)	0.89 (0.63 to 1.28)	1.23 (0.85 to 1.80)	0.73 (0.56 to 0.94)	1.01 (0.77 to 1.33)
Elbow	0.73 (0.54 to 0.97)	0.77 (0.57 to 1.03)	0.64 (0.46 to 0.89)	**0.70 (0.50 to 0.98)**	0.95 (0.70 to 1.30)	0.99 (0.72 to 1.37)	0.92 (0.64 to 1.32)	0.93 (0.64 to 1.37)	0.90 (0.60 to 1.34)	0.94 (0.62 to 1.42)	1.19 (0.93 to 1.53)	1.30 (0.99 to 1.70)
Forearm	0.91 (0.65 to 1.28)	1.08 (0.76 to 1.52)	0.53 (0.34 to 0.82)	**0.63 (0.40 to 0.99)**	0.72 (0.47 to 1.07)	0.85 (0.55 to 1.30)	0.80 (0.50 to 1.29)	0.96 (0.59 to 1.55)	0.74 (0.43 to 1.26)	0.90 (0.52 to 1.54)	0.98 (0.70 to 1.36)	1.17 (0.82 to 1.65)
Wrist	0.86 (0.70 to 1.07)	1.07 (0.86 to 1.34)	0.57 (0.43 to 0.74)	**0.74 (0.57 to 0.98)**	0.63 (0.48 to 0.82)	0.81 (0.62 to 1.07)	0.79 (0.58 to 1.06)	1.00 (0.74 to 1.37)	0.71 (0.50 to 0.99)	0.95 (0.67 to 1.34)	0.86 (0.70 to 1.07)	1.15 (0.91 to 1.44)
Hand	0.68 (0.53 to 0.88)	0.81 (0.62 to 1.05)	0.44 (0.32 to 0.61)	**0.57 (0.40 to 0.79)**	0.47 (0.34 to 0.66)	**0.59 (0.41 to 0.83)**	0.60 (0.41 to 0.87)	0.74 (0.50 to 1.09)	0.60 (0.40 to 0.91)	0.77 (0.50 to 1.18)	0.57 (0.44 to 0.75)	**0.74 (0.56 to 0.99)**
Fingers	0.85 (0.66 to 1.10)	0.91 (0.70 to 1.19)	0.63 (0.46 to 0.86)	**0.72 (0.52 to 0.99)**	0.65 (0.47 to 0.86)	**0.71 (0.51 to 0.99)**	0.80 (0.56 to 1.14)	0.93 (0.65 to 1.34)	0.71 (0.48 to 1.07)	0.81 (0.53 to 1.22)	0.75 (0.58 to 0.98)	0.84 (0.64 to 1.11)
Thoracic spine	0.75 (0.63 to 0.90)	**0.77 (0.64 to 0.93)**	0.83 (0.69 to 1.02)	0.90 (0.74 to 1.10)	0.71 (0.58 to 0.88)	**0.78 (0.63 to 0.97)**	0.69 (0.54 to 0.89)	**0.74 (0.57 to 0.97)**	0.54 (0.40 to 0.73)	**0.64 (0.47 to 0.87)**	0.63 (0.52 to 0.76)	**0.77 (0.63 to 0.93)**
Ribs	0.85 (0.59 to 1.21)	0.98 (0.68 to 1.42)	0.74 (0.49 to 1.11)	0.88 (0.58 to 1.34)	0.60 (0.38 to 0.95)	**0.74 (0.46 to 1.17)**	1.04 (0.66 to 1.62)	1.18 (0.73 to 1.88)	0.69 (0.39 to 1.22)	0.88 (0.50 to 1.57)	0.78 (0.54 to 1.11)	0.90 (0.62 to 1.36)
Lower back	0.91 (0.80 to 1.03)	0.93 (0.82 to 1.06)	0.85 (0.73 to 0.97)	0.91 (0.78 to 1.05)	0.77 (0.67 to 0.90)	**0.84 (0.72 to 0.97)**	0.69 (0.57 to 0.82)	**0.76 (0.63 to 0.91)**	0.85 (0.71 to 1.03)	0.96 (0.79 to 1.16)	0.79 (0.70 to 0.90)	0.93 (0.81 to 1.06)
Abdomen	0.70 (0.52 to 0.95)	0.94 (0.69 to 1.28)	0.45 (0.31 to 0.67)	**0.61 (0.41 to 0.91)**	0.68 (0.48 to 0.97)	0.97 (0.68 to 1.40)	0.67 (0.44 to 1.02)	0.89 (0.57 to 1.37)	0.91 (0.60 to 1.38)	1.33 (0.87 to 2.05)	0.60 (0.44 to 0.83)	0.82 (0.59 to 1.14)
Pelvis/Gluteals	1.00 (0.78 to 1.28)	1.11 (0.86 to 1.43)	0.77 (0.57 to 1.03)	0.86 (0.64 to 1.17)	0.92 (0.69 to 1.23)	1.13 (0.84 to 1.52)	1.02 (0.74 to 1.41)	1.15 (0.81 to 1.62)	0.96 (0.67 to 1.39)	1.19 (0.82 to 1.73)	1.10 (0.86 to 1.40)	**1.37 (1.06 to 1.76)**
Hip	1.06 (0.87 to 1.30)	1.05 (0.85 to 1.29)	0.93 (0.74 to 1.17)	0.96 (0.76 to 1.21)	1.05 (0.84 to 1.32)	1.09 (0.87 to 1.38)	0.93 (0.71 to 1.22)	0.97 (0.73 to 1.29)	1.24 (0.94 to 1.63)	**1.37 (1.03 to 1.81)**	0.97 (0.79 to 1.18)	1.17 (0.95 to 1.45)
Groin	0.94 (0.65 to 1.34)	1.04 (0.72 to 1.49)	0.72 (0.47 to 1.10)	0.80 (0.52 to 1.23)	0.98 (0.65 to 1.46)	1.05 (0.69 to 1.59)	1.08 (0.69 to 1.71)	1.20 (0.75 to 1.91)	1.31 (0.83 to 2.10)	1.40 (0.87 to 2.27)	1.28 (0.92 to 1.79)	1.40 (0.99 to 1.99)
Thigh	0.99 (0.75 to 1.31)	1.13 (0.85 to 1.51)	0.87 (0.63 to 1.19)	0.99 (0.71 to 1.38)	1.24 (0.92 to 1.68)	**1.41 (1.03 to 1.92)**	1.39 (0.99 to 1.95)	**1.59 (1.13 to 2.25)**	1.60 (1.13 to 2.27)	**1.82 (1.28 to 2.61)**	1.37 (1.05 to 1.78)	**1.51 (1.15 to 1.99)**
Knee	1.02 (0.88 to 1.19)	1.08 (0.92 to 1.25)	1.04 (0.88 to 1.22)	1.10 (0.93 to 1.30)	1.17 (0.99 to 1.37)	**1.25 (1.06 to 1.50)**	1.12 (0.93 to 1.36)	**1.22 (1.01 to 1.49)**	1.43 (1.18 to 1.75)	**1.55 (1.27 to 1.90)**	1.16 (1.00 to 1.34)	**1.30 (1.12 to 1.51)**
Lower leg	0.77 (0.59 to 1.00)	0.93 (0.71 to 1.21)	0.82 (0.62 to 1.07)	1.04 (0.78 to 1.39)	1.02 (0.77 to 1.34)	1.31 (0.98 to 1.73)	1.14 (0.83 to 1.55)	**1.43 (1.04 to 1.97)**	0.95 (0.66 to 1.36)	1.22 (0.85 to 1.77)	1.03 (0.81 to 1.31)	**1.34 (1.04 to 1.73)**
Ankle/Achilles	1.09 (0.87 to 1.36)	1.14 (0.90 to 1.43)	1.19 (0.93 to 1.52)	1.24 (0.96 to 1.59)	1.42 (1.12 to 1.81)	**1.47 (1.14 to 1.88)**	1.48 (1.12 to 1.94)	**1.55 (1.17 to 2.06)**	1.70 (1.28 to 2.26)	**1.79 (1.34 to 2.40)**	1.69 (1.37 to 2.08)	**1.85 (1.49 to 2.31)**
Foot/Toes	1.22 (0.99 to 1.52)	**1.28 (1.02 to 1.60)**	1.12 (0.88 to 1.42)	1.25 (0.98 to 1.61)	1.08 (0.84 to 1.38)	1.24 (0.96 to 1.60)	1.10 (0.82 to 1.47)	1.26 (0.93 to 1.71)	1.23 (0.91 to 1.67)	**1.50 (1.10 to 2.05)**	1.17 (0.94 to 1.45)	**1.53 (1.22 to 1.92)**

Continued

Table 2 Continued

Location of MSK pain	Dose of WHO guideline-based PA: 150–300 min, Crude OR (95% CI)	150–300 min, Adjusted OR (95% CI)	300–450 min, Crude OR (95% CI)	300–450 min, Adjusted OR (95% CI)	450–600 min, Crude OR (95% CI)	450–600 min, Adjusted OR (95% CI)	600–750 min, Crude OR (95% CI)	600–750 min, Adjusted OR (95% CI)	750–900 min, Crude OR (95% CI)	750–900 min, Adjusted OR (95% CI)	900+ min, Crude OR (95% CI)	900+ min, Adjusted OR (95% CI)

A group of participants who did not meet the WHO recommendations of PA (ie, PA less than 150 min per week) was set as the reference group. The model was adjusted for sex, age, employment status and depression risk. The numbers in bold denote significant results, and the CI that starts or ends with 1.0 derives from rounding the decimals.
MSK pain, musculoskeletal pain; PA, physical activity.;

Table 3 Association of PA with the number of MSK pain locations

No of MSK pain locations	Dose of WHO guideline-based PA: 150–300 min, Crude OR (95% CI)	150–300 min, Adjusted OR (95% CI)	300–450 min, Crude OR (95% CI)	300–450 min, Adjusted OR (95% CI)	450–600 min, Crude OR (95% CI)	450–600 min, Adjusted OR (95% CI)	600–750 min, Crude OR (95% CI)	600–750 min, Adjusted OR (95% CI)	750–900 min, Crude OR (95% CI)	750–900 min, Adjusted OR (95% CI)	900+ min, Crude OR (95% CI)	900+ min, Adjusted OR (95% CI)
Minimum one location	1.06 (0.95 to 1.18)	1.10 (0.98 to 1.23)	1.04 (0.93 to 1.17)	1.12 (0.99 to 1.27)	1.01 (0.89 to 1.14)	1.11 (0.98 to 1.26)	0.92 (0.80 to 1.06)	1.04 (0.90 to 1.20)	1.09 (0.80 to 1.28)	**1.28** (**1.10 to 1.51**)	1.05 (0.94 to 1.17)	**1.30** (**1.16 to 1.45**)
Minimum three locations	0.89 (0.78 to 1.01)	0.97 (0.85 to 1.11)	0.80 (0.70 to 0.93)	0.90 (0.78 to 1.04)	0.80 (0.69 to 0.93)	0.93 (0.80 to 1.08)	0.86 (0.72 to 1.02)	1.00 (0.84 to 1.19)	0.93 (0.77 to 1.12)	1.12 (0.93 to 1.36)	0.88 (0.77 to 0.99)	1.08 (0.94 to 1.23)
Minimum five locations	0.76 (0.62 to 0.93)	0.84 (0.69 to 1.03)	0.65 (0.51 to 0.82)	**0.75** (**0.60 to 0.95**)	0.61 (0.48 to 0.78)	**0.73** (**0.57 to 0.93**)	0.74 (0.56 to 0.97)	0.85 (0.64 to 1.13)	0.87 (0.66 to 1.16)	1.09 (0.82 to 1.45)	0.83 (0.68 to 1.01)	1.06 (0.87 to 1.29)
Minimum ten locations	0.70 (0.45 to 1.07)	0.76 (0.49 to 1.17)	0.32 (0.17 to 0.61)	**0.36** (**0.19 to 0.68**)	0.57 (0.34 to 0.98)	0.64 (0.37 to 1.10)	0.64 (0.35 to 1.19)	0.67 (0.35 to 1.40)	0.62 (0.31 to 1.23)	0.70 (0.35 to 1.40)	0.61 (0.39 to 0.95)	0.67 (0.42 to 1.06)

A group of participants who did not meet the WHO recommendations of PA (ie, PA less than 150 min per week) was set as the reference group. The model was adjusted for sex, age, employment status and depression risk. Significant OR's are marked bold.

MSK pain, musculoskeletal pain; PA, physical activity.;

DISCUSSION

The purpose of this study was to explore the relation between PA and MSK pain. Previous research focused on the impact of PA on specific locations of MSK pain (eg, low back and neck[20]) or certain occupational settings.[11 12] Our large-scale multinational study is novel in that it identified the associations between different degrees of compliance to PA recommended by WHO and multiple body locations in the general population after adjusting for multiple cofounding factors including age, which is known to be positively associated with MSK pain prevalence.

Guideline compliance (150–300 min per week) was weakly associated with MSK pain, showing lower odds of having pain only in thoracic spine but higher odds in foot/toes. In contrast, double compliance (300–450 min per week) substantially increased the number of locations that were associated with lowers odds of MSK pain to six and thus seems to represent the optimal dose when PA is undertaken to prevent MSK. Finally, higher levels of PA (triple to top compliance) were associated with less odds of having pain in multiple upper body locations but paradoxically contributed to higher odds of having lower extremity pain. Notably, participating in 300–600 min of PA per week was associated with lower odds of having pain in upper extremities, neck and thoracic and lumbar spine. In contrast, participating in greater than 450 min of PA per week was associated with higher odds of having pain in the lower extremity.

Time spent in PA and pain in neck, back and upper extremity

A previous systematic review showed that there was limited evidence for no association between PA and neck pain.[20] However, our study found that participating in PA between 450 and 900+ min was associated with lower odds of having pain in neck/cervical spine. Several epidemiological studies have demonstrated that certain postures sustained for prolonged duration combined with sedentary lifestyle were associated with neck pain.[21–23] Therefore, increased PA levels may be helpful to consider in those at risk for neck pain.

Association between PA and thoracic spine has been less explored,[24] but a recent observational study found that PA less than 150 min per week was associated with reduced thoracic mobility.[25] Our findings build on previous research in that PA less than 150 min per week is also associated with higher odds of having pain in the thoracic spine.

While it is generally accepted that PA and exercise are beneficial in the management of acute and chronic low back pain, a previous systematic review could not identify either positive or negative relationship.[26] One study suggested that the relationship between the level of activity and back pain might be explained by a U-shaped curve that suggests both low and excessive PA may increase the risk of low back pain.[27] Our findings partly support this concept as PA of 450–750 min was associated with lower odds of low back pain while lower or higher PA than that range did not have significant association.

PA in the range of 300–600 min was also associated with lower odds of having pain in several locations in the upper extremity such as elbow, forearm, wrist, hand and fingers. PA exceeding 750 min was associated with higher odds of shoulder pain. The underlying mechanisms of how PA modulates pain are not completely understood, but several pathways have been proposed. Animal study findings suggest regular PA may act on the central nervous system (CNS) and alter rate of pain hypersensitivity, dysregulation of pain modulation and development of chronic pain.[28–30] In humans, it has been proposed that PA may intervene excitability and inhibition in the CNS,[31–33] and anti-inflammatory and antioxidant effects of regular PA might diminish the processes contributing to central sensitisation.[34–36] Other proposed mechanisms in humans include the activation of opioid and serotonin pathways[37] or involvement of endocannabinoid system[38] induced from regular PA which could exert analgesic effects. While further research is needed to elucidate how much and what type of PA can induce such changes to modulate pain, our results suggest that PA between 300 and 600 min per week may be sufficient for spinal conditions and upper extremity pain, with PA exceeding 750 min associated with higher likelihood of shoulder pain.

Association of PA and lower extremity pain

The association of PA to lower extremity pain was different than what was observed for upper extremity and spine conditions. Our results suggest PA exceeding 450 min was associated with higher odds of MSK pain in lower extremity. These findings may be partially explained by higher amounts of PA are likely to involve greater use of the lower extremity. In the USA, it has been reported that walking is the most popular form of exercise followed by biking, yard work, strength training, dancing and running, which are activities that commonly place physical demands through the lower extremity.[39] Running is one of the most popular exercises in the world and has been shown to result in lower extremity pain in multiple anatomical locations with nearly all (94.7% of runners) reporting experience of pain at least once after running.[40]

We also observed that greater PA was associated with a higher number of sites of MSK pain in the lower extremity. A dose response was observed: 450–600 min was associated with pain in three anatomical regions, 600–750 min with pain in four anatomical regions, 750–900 min with five anatomical regions, and 900+ min with six anatomical regions. The optimal PA level to reduce pain in those with existing musculoskeletal lower extremity pain is unknown. A prior study reported that a minimum of 45 total moderate-vigorous min per week was sufficient to elicit improved or sustained high function with lower-extremity symptoms regardless of age, gender, body mass index or presence of knee osteoarthritis.[41] Our findings of PA ranging from 150 to 450 min not increasing the odds of having pain in the lower extremities suggest this range might be appropriate to be safe and promote other health benefits.

Clinical implication

While the WHO 2020 guidelines on PA recommend 150–300 min of moderate-intensity PA, or 75–150 min of vigorous-intensity PA, or some equivalent combination of moderate-intensity and vigorous-intensity aerobic PA per week for optimal health outcomes,[8] the current study suggests that more PA beyond the WHO recommendation may be necessary to decrease the odds of having pain particularly in the upper extremity. Our findings suggest a target of 300–450 min of PA per week could be optimal for preventing pain in the upper extremity without clear associated higher rate of lower extremity pain. Also, this range was associated with lower odds of having pain in multiple number of locations. Recognising concerns on higher prevalence of pain in low back, neck, and thoracic spine increased during the COVID-19 pandemic,[15] PA target of the higher target of 450 min of weekly exercise may be helpful in this population. Our results suggest exceeding 450 min of PA may not be advisable for those with increased concern for lower extremity pain. Furthermore, PA above 750 min was associated with having at least one pain location.

Limitation

While our findings derived from a large-scale multinational study of participants, we do note potential limitations. Self-report of PA and MSK pain are limited by reporting bias and inaccuracy including risk for over-reporting level of PA.[42 43] The cross-sectional study design limits our understanding between PA and the aetiology of MSK pain. Also, we are limited in ability in discriminating the types of PA to report of MSK pain by anatomical locations. We were not able to distinguish or identify bilateral MSK pain from our questionnaire as well. Furthermore, because a separate analysis was run for each body region, there is a risk of multiple testing problem. Since our analysis was explorative in nature, further prospective cohort or interventional studies are needed to elucidate the best form and dose of PA to address MSK pain by anatomical location and specific musculoskeletal injury, and additionally investigate the role of MSK pain intensity instead of using a binary (yes/no) classification.

CONCLUSION

Our findings showed that PA time above the WHO recommendations was associated with lower odds of having pain in multiple locations such as neck, thoracic spine, low back and in the upper extremities. Especially, undertaking PA for 300–450 min per week was associated with reduced pain occurrence in six locations, elbow, forearm, wrist, hand, fingers and abdomen.

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