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Bidirectional Associations between Pain and Physical Activity in Adolescents

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Abstract

Objectives—The objectives were to: 1) examine temporal relationships between pain and activity in youth, specifically, whether physical activity affects pain intensity and whether intensity of pain affects subsequent physical activity levels on a daily basis, and 2) examine clinical predictors of this relationship.

Methods—Participants were 119 adolescents (59 with chronic pain and 60 healthy) aged 12–18 years, 71% female. Adolescents completed 10 days of actigraphic monitoring of physical activity and daily electronic diary recordings of pain intensity, medication use, sleep quality, and mood. Linear mixed models assessed daily associations among physical activity and pain. Daily mean (average count/min) and peak (highest daily level) activity were used for analyses. Medication use, sleep quality and mood ratings were included as covariates, and age, gender and BMI percentile were adjusted for.

Results—Higher pain intensity was associated with lower peak physical activity levels on the next day ($t(641) = -2.25, p = 0.03$) and greater medication use predicted lower mean physical activity levels the same day ($t(641) = -2.10, p = 0.04$). Higher mean physical activity levels predicted lower pain intensity ratings at the end of the day ($t(705) = -2.92, p = 0.004$), but only in adolescents with chronic pain.

Discussion—Youth experiencing high pain intensity limit their physical activity level on a day-to-day basis. Activity was related to subsequent pain intensity, and may represent an important focus in chronic pain treatment. Further study of the effect of medications on subsequent activity is needed.

Keywords

actigraphy; medication; daily electronic diary; function; disability

INTRODUCTION

Enhancing physical functioning (i.e., participation in physical activities, ability to perform physical tasks) is an important treatment goal¹ for adolescents with chronic pain, who as a group, demonstrate decreased physical function compared to healthy youth^{2,3}. Physical function has been fairly extensively studied in youth with various pain conditions wherein

youth or their parents have reported on perception of difficulty in the child's participation in developmentally appropriate activities due to pain^{4,5}. Such studies have documented that decreases in physical functioning are common, in particular, limitations in vigorous physical activities such as sports. It has been estimated that up to 75% of youth with chronic pain withdraw from participating in sports activities, with these children and adolescents also experiencing reductions in other activities, including gym class, playing, running, and walking^{6,7}. This is cause for concern given that greater limitations in activity are related to decreased overall physical functioning, reduced psychosocial functioning, and reduced quality of life in youth with chronic pain⁸.

However, perception of limitation in activities is a different construct from physical activity or actual bodily activity. Physical activity is a component of physical functioning that can be defined as any bodily movement produced by skeletal muscles resulting in caloric expenditure⁹, and can be measured via self-report, proxy-report, or via activity monitors such as pedometers or actigraphic monitoring devices. Physical activity and exercise has repeatedly been shown to be relevant to the treatment of adults with chronic pain conditions^{10,11}; however, physical activity has been studied less in pediatric populations. Only three studies to date have used actigraphy, a watch-like device which records movement, to examine physical activity levels and patterns in youth with chronic pain. Two studies compared adolescents with mixed chronic pain problems (headaches, abdominal pain, and musculoskeletal pain) to matched healthy controls on actigraphic measures of daytime activity, and found lower activity levels and more time spent in sedentary activity among youth with chronic pain^{12,13}. In a study of adolescents with juvenile fibromyalgia, those adolescents who engaged in the least amount of actigraphic-measured physical activity reported significantly more pain than those adolescents who engaged in the highest amount of physical activity¹⁴. Moreover, higher activity was associated with significantly lower levels of self-reported pain intensity, depressive symptoms, and functional disability¹⁴.

One question that has not been addressed in prior studies on physical activity in youth with chronic pain is the temporal or directional path between pain and activity. While research demonstrates that pain of higher intensity is associated with lower physical activity overall, previous research in this area has exclusively focused on group differences^{15–18}, and temporal associations have not been examined. Therefore it is not clear if daily physical activity impacts subsequent pain intensity and whether intensity of daily pain impacts subsequent physical activity. For example, higher pain levels may disrupt or reduce physical activity; in turn, lower physical activity levels may increase or exacerbate pain. A number of clinical factors may also influence this association. Prior studies have found associations among pain, depressive symptoms, and physical activity¹². Moreover, poorer sleep quality is related to daily pain and greater activity limitations^{19,20} in adolescents with chronic pain. Medication use in adolescents with chronic pain may have considerable impact on relationships between pain and activity. Numerous medications are used for pediatric chronic pain management including opioids, antidepressants, anticonvulsants, benzodiazepines, antihistamines and sleep medications²¹. Presumably one of the primary goals of the use of these medications is improvement in quality of life and functioning of the adolescent. However, the impact on daily function, either positive or negative, of these medications in this population has not been well explored. One study in young adults with chronic pain found that use of opioid medication was associated with decreased activity levels²². However, the effect of combinations of these medications on physical functioning in youth has not been studied and may have important treatment implications. A more thorough understanding of the temporal relationship between pain and physical activity, along with commonly associated factors, may have meaningful clinical implications and help guide behavioral and physical therapy rehabilitation treatments for children with chronic pain.

When studying physical activity in the adolescent population it is particularly useful to use healthy comparator groups because this is a developmental stage during which many changes are already occurring in physical activity patterns. In early adolescence, a naturalistic decline in levels of physical activity occurs and is most pronounced in females and in ethnic minorities. For example, in a survey conducted using the Centers for Disease Control health surveillance tool, only 18% of adolescents were physically active in a moderate or vigorous physical activity for at least 60 minutes per day, and only 33% regularly attended physical education classes²³. Thus, in the context of low overall physical activity levels in youth, the relationship between pain and activity is particularly important.

Thus, the aims of this study were threefold: 1) to examine daily levels of pain and physical activity in a clinical sample of adolescents with chronic pain as compared to healthy youth, 2) to examine reciprocal associations between pain and physical activity, and 3) to examine predictors of activity and pain including sleep quality, mood ratings, and medication use across the two groups. We hypothesized that youth with chronic pain would have greater pain and lower physical activity in comparison to healthy youth. Furthermore, we hypothesized a bidirectional relationship between pain and physical activity such that physical activity would predict end of day pain and end of day pain would predict physical activity levels the next day. Finally, we hypothesized that worse mood, poor sleep quality, and higher medication use would be associated with greater daily pain and reduced daily physical activity.

METHODS

Participants were 119 adolescents aged 12–18 years (59 with chronic pain and 60 healthy participants) taking part in a larger longitudinal study of sleep patterns over 12 months. The present report is focused exclusively on the 10 day data collection period conducted at study enrollment. Other manuscripts published from this data set have examined sleep patterns in adolescents with and without chronic pain and sleep disturbances in adolescents with depressive disorders^{13,20,24,25}. One previous manuscript examined temporal associations among pain and sleep²⁰. This is the first paper to examine temporal associations among pain, medication use and physical activity.

Participants

Adolescents with chronic pain were a clinical sample of youth recruited from a tertiary care pediatric pain clinic. All patients aged 12–18 years that were undergoing an initial evaluation at the pain clinic were approached in clinic or invited to participate in the study via a letter sent to their home immediately following their clinic visit. Adolescents with chronic pain were eligible for participation if: 1) they were between 12–18 years old, 2) experiencing pain at least three times a week for a minimum of three months, 3) pain was not related to a chronic medical condition (e.g. arthritis, cancer), 4) participants did not have a developmental disability via parent report, and 5) the adolescent and their parent spoke and read English.

Healthy adolescent participants were recruited from advertisements posted in the local community (e.g., schools, libraries). Families interested in participating contacted the study coordinator via phone who explained the study and determined eligibility. Healthy adolescents were eligible to participate if: 1) they were between 12–18 years old, 2) per parent report did not have a history of chronic pain or other chronic medical condition (e.g. arthritis, cancer), 3) did not have a developmental disability via parent report, and 4) the adolescent and their parent spoke and read English. Over time, healthy adolescents were more narrowly recruited by age and sex (based on means and frequencies of the chronic pain

group on these variables) in order to ensure equivalence of the study groups on these characteristics.

Participation rate

Over an 18 month recruitment period, 97 adolescents with chronic pain were contacted and invited to participate in the study. Of those invited, 59 were enrolled, 20 were excluded because they failed to meet inclusion criteria, 16 declined and 2 were excluded for insufficient data. One hundred and seven healthy adolescents contacted the study coordinator seeking to participate. Of those participants, 60 were enrolled, 41 were excluded because they failed to meet inclusion criteria, and 6 declined. The primary reason for refusal in both groups was time commitment associated with participation.

Procedures

After determining eligibility via phone, researchers met participants at their homes or agreed-upon public location (e.g., library). Researchers obtained informed consent from both parents and adolescents, and administered self-report and interview questionnaires. Parents completed a basic demographic form, which provided information on the adolescent's age, race, sex, height and weight, and family income. Adolescents completed a questionnaire reporting pain location on a validated body diagram and they completed the Center for Epidemiological Studies Depression Scale (CES-D)²⁶ to assess baseline depressive symptoms. During this visit, participants were also given instructions for: 1) completing electronic diaries (Palm® PDA with custom software) to record daily pain, medication use, mood, and sleep quality; and 2) wearing the Actiwatch to record daily activity levels. Participants were instructed to complete the electronic diary two times each day (morning and evening) for the 10-day data collection period. Each morning, adolescents rated their current mood and sleep quality from the previous night. Each evening, adolescents rated their pain intensity and use of medications that day. Adolescents were asked to refrain from making any changes to their usual medication regimen during the 10-day study period. Electronic diaries and Actiwatchs were returned to research staff via mail. Families received \$30 gift cards for their participation.

Measures

Activity—Objective recordings of daily physical activity were assessed with wrist actigraphy using an Actiwatch (Actiwatch 64, Phillips Respironics, Bend, OR). The watch-like device was worn by adolescents on their non-dominant wrist for the 10-day study period. Movement is sensed by an omni-directional mercury switch that is open when there is no movement and closed when movement above a set threshold is detected. Each time the switch closes, an activity count is generated. Counts were stored on the device in 1 minute epochs. Activity intervals were determined via event markers (button on the device pushed by participants at bedtime and wake time). In the event that no clear sleep or wake event marker was available, sleep onset and offset time was determined based on 10 contiguous minutes below the sleep threshold set by the software. Any periods during daytime waking hours when the device was not worn (defined as 10 or more contiguous minutes of activity counts of 0) were excluded by hand from the wake interval. Moreover, if participants had less than 7 hours of data in the activity interval that day's data was excluded from analyses.

Two actigraphic activity variables were computed using the Actiware 5.0 software package: 1) mean activity per minute calculated as the mean number of activity counts per 1 minute epoch during each daytime wake period, and 2) peak activity achieved each day calculated as the highest number of activity counts achieved in a single 1 minute epoch per daytime wake period. These variables have been used in prior research to represent physical activity patterns in adolescents with pain^{12,13}. Daily mean activity and peak activity were used in the

models. For descriptive purposes, these variables were averaged for the 10 day period for each individual and then summary variables were averaged for group statistics. Wrist actigraphy has been validated in the assessment of activity in both healthy adolescents^{27,28} and adolescents with chronic pain¹³.

Pain Intensity—Adolescents rated their daily pain intensity once each day in the evening using an 11-point numerical rating scale (NRS), with higher ratings associated with more intense pain (0 = no pain, 10 = worst pain). Numerical rating scales are a valid and reliable assessment tool and have been recommended for assessment of pain intensity for both acute²⁹ and chronic pain in adolescents³⁰.

Medication use—Each evening, adolescents reported if they had taken any medication that day. Adolescents who responded “yes” were then instructed to record the name of the medication(s) taken, either by selecting from a list pre-populated with their current daily medications or as a free text entry. For analysis, medications were coded into classes (over the counter pain medications, opioids, other pain medications, sleep medications, antidepressants, anticonvulsants, benzodiazepines and antihistamines) by research staff. The total number of medication classes used each day was summed and used in the models. This variable was chosen to reflect the degree of polypharmacy and potential for additive side effects of medication use among each participant, which was felt to have the most potential impact on physical activity.

Sleep Quality—Adolescents gave a morning rating of their sleep quality from the previous night using an 11-point NRS, with lower ratings representing poorer sleep quality (0 = extremely poor sleep, 10 = extremely good sleep). Global ratings of sleep quality have been used in other studies in youth³¹.

Mood—Adolescents rated their mood each morning on an 11-point NRS, with higher ratings representing more positive mood (0 = extremely bad/negative mood, 10 = extremely good/positive mood). Global mood ratings have been used in other diary studies³¹.

Body Mass Index—Parent reported height and weight of the adolescent were entered in the Centers for Disease Control and Prevention’s online pediatric Body Mass Index (BMI) calculator, to obtain BMI percentile. BMI percentiles are based on nationally established norms of BMI for the child’s gender and chronological age and have been used in previous studies with pediatric pain samples³².

Statistical Analyses

Demographic characteristics of the sample were summarized using descriptive statistics. Frequency statistics were used for categorical variables; means and standard deviations described continuous data. T-tests and chi-square tests were conducted to test for potential differences between groups (adolescents with chronic pain and healthy participants) on age, gender, racial background, BMI, predictor variables and outcome variables. Pearson product moment correlations were used to assess the association between continuous predictor and outcome variables.

Linear mixed effects models were used to estimate the magnitude and direction of association in changes in the predictor variable with changes in the outcome variable. Specifically, linear mixed modeling examined whether (1) daily pain intensity predicted next day mean and next day peak activity levels and whether (2) daily mean and daily peak activity levels predicted end of day pain. Previous literature has suggested that age, gender and BMI can be associated with physical activity¹³, thus all models adjusted for these

variables. Group status (healthy or chronic pain), previous night sleep quality, same day number of medication categories used, and same day mood were also included as covariates. The linear mixed modeling procedure is flexible in that it allows for the examination of temporal relationships between variables with different numbers of observations (diary days) due to missing data³³. Participants with at least three days of simultaneous diary and actigraphy data were included in the analysis. We applied a series of linear mixed models assessing the associations between daily pain and daily physical activity. A subject specific random effect was included in all of the models to account for within-subject correlation; all other predictors were treated as fixed effects. Up to 10 study days were nested within 119 participants. *Level 1* variables were those measured on a repeated basis (pain intensity, physical activity, sleep quality, mood, and medication use). Variables that were measured once (study group, gender, age, and BMI) contained only between-person variance and were modeled as *Level 2* variables. Analyses focused on the within-subject relationship between pain and physical activity using a combined study sample. Between-subject differences were examined when study group modified the relationship between pain and physical activity. Data analyses were conducted using the Proc Mixed procedure in SAS Version 9.2 (SAS 9) and the Statistical Package for the Social Sciences Version 18.0 (SPSS 18.0). Significance levels were set at $p < 0.05$.

RESULTS

Descriptive data

Adolescents had a mean age of 15.0 years ($SD = 1.7$) and 71% were female. Mean age-corrected BMI percentile was 62.3 ($SD = 27.9$), and 31% of the sample were in the overweight or obese range (BMI percentile = 85). As shown in Table 1, there were no significant differences in age, gender, race or BMI between healthy adolescents and adolescents with chronic pain. Clinically significant depressive symptoms were reported by 15% of healthy adolescents and 29% of adolescents with chronic pain.

The three most frequently reported primary sites of pain were legs (21%), head (17%) and abdomen (13%) in healthy adolescents, and head (34%), abdomen (27%) and legs (15%) in adolescents with chronic pain.

Fourteen healthy adolescents (23%) used one or more of the listed medication categories during the study period, while 49 adolescents (83%) with chronic pain used one or more of the medication categories. The medications used by the highest number of participants were NSAIDs/acetaminophen and antihistamines by healthy adolescents, and anticonvulsants and antidepressants by adolescents with chronic pain.

Daily pain and average physical activity: diary and actigraphy data

A total of 1106 days of diary and actigraphy data were used for analysis, with an average of 9 days ($SD = 1.6$; range 3 to 12 days) of simultaneous diary and actigraphy data per adolescent. On average 15.5 hours ($SD = 2.3$) of actigraphy data was available for each day.

On average, mean daily activity was light ($M = 472$ counts/min, $SD = 138$) for all participants during the 10-day period and peak daily activity was moderate ($M = 3272$ counts/min, $SD = 942$). As shown in Table 2, mean physical activity levels were 14% lower for adolescents with chronic pain as compared to healthy adolescents and peak physical activity levels were 20% lower for adolescents with chronic pain.

Over the 10 day study period, adolescents with chronic pain reported moderate levels of daily pain intensity ($M = 5.6$, $SD = 2.3$), while healthy adolescents reported low intensity pain ($M = 1.2$, $SD = 1.2$).

Average daily medication use—Participants with chronic pain used medication on 69.7% of days while healthy participants used medication on 4.2% of days, representing a significant difference between groups (see Table 3). For both adolescents with chronic pain and healthy adolescents, the number of medication categories used on that day significantly correlated with mean ($r = -0.241, p = < 0.001$) and peak ($r = -0.195, p = < 0.001$) physical activity the same day, with greater number of medication categories used associated with lower activity levels.

Average daily sleep and mood quality—Average sleep quality was moderate ($M = 6.1, SD = 1.6$) across the 10-day study period for the total sample of adolescents. Poorer self reported sleep quality was correlated with lower mean ($r = 0.126, p = < 0.001$) and peak ($r = 0.110, p = 0.001$) physical activity the following day. Average mood rating was moderately positive ($M = 6.0, SD = 1.6$) for both groups of adolescents. Daily mood was weakly but significantly correlated with mean ($r = 0.097, p = 0.003$) and peak ($r = 0.103, p = 0.002$) physical activity, with more negative mood associated with lower activity. As expected, both sleep quality and mood were rated significantly lower in adolescents with chronic pain compared to healthy peers (see Table 2).

Daily associations between pain, medication use and activity

Pain predicts next day physical activity—Shown in Table 4, two separate models evaluated pain as a predictor of next day mean and peak physical activity. As hypothesized, for the total sample pain predicted next day peak physical activity, with higher pain intensity associated with lower peak physical activity levels on the next day ($t(641) = -2.25, p = 0.03$). Pain was not a significant predictor of next day mean activity ($t(641) = 0.04, p = 1.0$). Additionally, greater medication use predicted lower mean physical activity levels the same day ($t(641) = -2.10, p = 0.04$), although it was not associated with peak physical activity levels ($t(641) = 0.33, p = 0.7$). Contrary to hypotheses, neither previous night sleep quality, study group, or same day mood were significant predictors of physical activity.

Physical activity predicts end of day pain—Two separate models evaluated mean and peak physical activity as predictors of pain at the end of the day (see Table 5). As hypothesized for the total sample, mean physical activity predicted pain intensity ratings at the end of the day ($t(705) = -2.92, p = 0.004$), with higher activity levels associated with lower pain. In terms of covariates, greater medication use ($p = 0.003$), previous night sleep quality ($p = 0.03$), and study group ($p < 0.001$) were also significant predictors of end of day pain in the model examining associations among mean activity and pain. Mood did not emerge as a significant predictor. Results revealed a significant interaction between group and average activity suggesting the associations among average physical activity and pain differ by study group ($t(705) = 2.96, p = 0.003$). To further examine this effect we ran the models separately by study group, and found that the average activity predicted end of day pain only for youth with chronic pain ($t(341) = -2.15, p = 0.03$), with higher activity associated with lower pain intensity at the end of the day. Similarly for the chronic pain sample only, greater medication use was associated with lower end of day pain ($p = 0.002$). Contrary to hypotheses, the associations between peak activity and end of day pain were not significant for the total sample or analyses conducted by study group.

DISCUSSION

Our primary objective was to test a bidirectional relationship between pain and physical activity in adolescents with and without chronic pain. As hypothesized, findings demonstrated a bidirectional relationship between pain and physical activity such that physical activity predicts end of day pain and end of day pain predicts physical activity

levels the next day. Higher daily pain intensity predicted reduced next day physical activity in youth; however this was only true for peak activity and not mean activity. This would suggest that youth experiencing high pain intensity in turn limit their physical activity level on a day-to-day basis. These findings extend prior retrospective studies of physical functioning in youth with chronic pain that have also reported that higher pain intensity is related to greater physical activity limitations³⁴. The alternate direction of the pain and activity relationship was also supported by our data, such that higher daily levels of mean physical activity were associated with less intense end of day pain. Moreover, this relationship only held in youth with chronic pain. It may be that physical activity does not increase pain in individuals who are already coping with chronic pain; however, an equally valid interpretation of our findings is that pain that is better controlled on a given day may enable children to achieve higher levels of physical activity. The difference in this relationship between healthy children and children with chronic pain may in part be due to differences in pain perception (e.g., lower pain intensity) reported by healthy adolescents compared to adolescents with chronic pain. Healthy youth had lower pain ratings and also showed less variability in pain ratings over the study period, possibly attenuating the relationship between pain and activity for the healthy sample. Additional work is needed to further examine this relationship in healthy adolescents as well as to uncover the sequential and possibly lagged relationships between pain and physical activity observed here in adolescents with chronic pain.

Several clinical covariates were examined in our models including sleep quality, mood, and medication use. Importantly, our mixed modeling approach allowed us to examine how daily changes in these covariates predicted changes in the outcome variables (physical activity, pain), as opposed to examining relationships with baseline summary levels only. Findings revealed a strong relationship for daily medication use to influence the daily association between pain and physical activity. Greater medication use predicted lower mean physical activity levels on the same day, and was significantly related to same day pain intensity. Similar to previous research²⁰, previous night sleep quality was also a significant predictor of end of day pain; however sleep quality was not found to influence daily physical activity levels. Although mood was related to pain and activity overall, daily mood ratings did not contribute to the daily temporal relationship between pain and activity.

Our findings concerning the relationship between medication use, pain, and activity is novel and important, particularly, since medication use can be quite frequent among youth receiving treatment for chronic pain. In our sample, adolescents with chronic pain used medication on the vast majority of days during the assessment (69.7% of days). There has been limited focus on either benefit from medication or on side effects/adverse effects from medication in youth with chronic pain³⁵. Further study of the effect of medications, in particular using dosage information and evaluating immediate effects following dosing, on subsequent activity is needed to extend our preliminary findings reported here.

Our findings should be interpreted in light of several limitations. As mentioned, medication use was self-reported and limited to medication classes taken each day; we were not able to quantify doses. Furthermore, there is likely variability in whether youth were taking medication at a therapeutic dose, as youth were recruited into the study following their initial clinic visit. Given the scarce information available on the impact of medications on youth physical functioning, these findings are a useful starting point, but further work is needed, especially regarding the relationship between individual medication classes and physical activity. Our study is also limited in that we were not able to examine all known risk factors that may influence activity levels in youth with pain. The relationship between the severity of pain and physical activity/functioning is not linear, and all children with severe pain are not necessarily limited or impacted in their physical activity³⁶. For children

and adolescents with chronic pain, additional risk factors such as withdrawal, pain-related fear, family characteristics, parent behaviors, and biologically-based factors likely influence activity participation^{37,38} and their inclusion in future studies will be important. Finally, diary data on pain and mood were only collected once each day, which may not have captured fluctuations in these symptoms throughout the day and may have introduced reporting bias such as the peak and end effect. Future studies should utilize techniques such as electronic momentary assessment to capture within-day variation in pain ratings.

Our findings suggest several clinical implications for assessment and management of physical activity in youth with chronic pain. As a component of overall physical functioning, physical activity is an important domain to assess in the comprehensive evaluation of the child or adolescent with chronic pain. Standardized questionnaires are available to assess activity and exercise patterns in youth^{39,40}. Activity monitoring devices while primarily used for research purposes can also provide objective information about activity patterns. Physical function is a central target in the management of pediatric chronic pain, and is often addressed in interdisciplinary treatment as well as specifically in psychological treatment and in physical therapy/rehabilitation. A variety of interventions including cognitive strategies, operant strategies, behavioral activation, and relaxation training may all be used toward the goal of increasing activity participation. In addition, physical therapy based interventions in children with chronic pain such as therapeutic exercise programs may also target overall physical activity level. Our findings of a temporal path between changes in activity and subsequent pain intensity highlights the importance of incorporating a focus on continuing to be active despite high pain intensity, consistent with a rehabilitation approach, when treating youth with chronic pain. There are limited data on children's physical activity levels before and after treatment for chronic pain. However, this is an important outcome to re-evaluate on routine follow up visits. It is also unclear whether specific exercise interventions may be beneficial in pediatric pain populations. In the few studies conducted to date, aerobic exercise programs have been effective in reducing pain in community-based samples of adolescents with low back pain⁴¹, and in clinical samples of youth with fibromyalgia⁴². Future research is needed to understand the potential benefits of physical activity interventions in youth with chronic pain.

There are also implications for future research on physical activity in youth with pain. While there are limitations to self-report of physical activity in children and adolescents, particularly among those with chronic pain¹⁴, additional research in this area is needed. In particular, psychometric properties of available self-report measures are needed to understand how these measures perform in pain populations. Additional work is needed with activity devices (e.g., actigraphy) to develop normative data in pediatric pain populations and understand relative levels of impairment. In particular, it will be important to develop standard methods of scoring actigraphy data for daytime activity levels, and of categorizing activity as sedentary, light, moderate, or vigorous in order to better make comparisons across studies.

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TABLE 1

Demographic data

	Pain, N = 59	Healthy, N = 60	Total, N = 119	P*
Age	15.1 (1.7)	14.8 (1.8)	15.0 (1.7)	0.38
Gender				
Male	17 (29)	17 (28)	34 (29)	0.95
Female	42 (71)	43 (72)	85 (71)	
Race and Ethnicity				0.33
Caucasian non-Hispanic/Latino	46 (78)	41 (68)	87 (73)	
Caucasian Hispanic/Latino	5 (8)	6 (10)	11 (9)	
African American	0 (0)	7 (12)	7 (6)	
American Indian	2 (3)	1 (2)	3 (3)	
Asian	1 (2)	1 (2)	2 (2)	
Other/missing	5 (8)	4 (7)	9 (8)	
BMI percentile (age corrected)	64.0 (27.9)	60.6 (28.0)	62.3 (27.9)	0.50

Data presented as M (SD) for continuous variables, n (%) for categorical variables

* t-test for independent samples used for continuous variables and chi-square test for categorical variables

TABLE 2

Average daily pain, physical activity, sleep quality and mood ratings in adolescents

	Pain, N = 59 M (SD)	Healthy, N = 60 M (SD)	Total, N = 119 M (SD)	P*
Pain level	5.6 (2.3)	1.2 (1.2)	3.4 (2.9)	<0.001
Activity				
Mean activity	436 (150)	507 (117)	472 (138)	0.004
Peak activity	2899 (843)	3637 (896)	3272 (942)	<0.001
Sleep quality	5.2 (1.3)	6.9 (1.4)	6.1 (1.6)	<0.001
Mood	5.3 (1.3)	6.5 (1.5)	6.0 (1.6)	<0.001

Data presented as M (SD)

*
t-test for independent samples

TABLE 3

Medication use (number of study days) by participants

	Pain, N = 547 n (%)	Healthy, N = 566 n (%)	Total, N = 1113 n (%)	<i>p</i>[*]
NSAID/Acetaminophen	87 (15.9)	22 (3.9)	109 (9.8)	
Opioid	37 (6.8)	1 (0.1)	38 (3.4)	
Other pain	16 (3.8)	0 (0)	16 (1.9)	
Sleep	32 (2.7)	0 (0)	32 (2.1)	
Antidepressant	198 (36.2)	0 (0)	198 (17.8)	
Anticonvulsant	238 (43.5)	0 (0)	238 (21.4)	
Benzodiazepine	21 (5.9)	0 (0)	21 (2.9)	
Antihistamine	15 (2.9)	9 (1.6)	24 (1.4)	
Any medication⁺	381 (69.7)	24 (4.2)	405 (36.4)	<0.001

N = total number of study days

*
chi-square test⁺
number of days that any listed medication was used

TABLE 4

Summary of linear mixed models examining pain as a predictor of next day physical activity

	Total group, N = 119	Pain group, N = 59	Healthy group, N = 60
	β (SE)	β (SE)	β (SE)
Mean activity			
Pain	0.31 (7.31)	-0.07 (3.28)	-5.33 (3.60)
Medication use	-18.71 (8.92) *	-16.87 (11.05)	-13.83 (23.08)
Mood	-3.36 (3.28)	-1.71 (4.27)	-3.97 (4.82)
Sleep quality	5.48 (3.11)	8.92 (4.16) *	2.91 (4.66)
Group	30.45 (27.72)		
Pain * Group interaction	-2.38 (4.78)		
Peak activity			
Pain	-147.48 (65.71) *	-46.17 (26.52)	31.78 (38.36)
Medication use	23.61 (71.11)	-39.72 (76.01)	433.38 (248.68)
Mood	-20.70 (31.73)	-12.83 (38.51)	-18.59 (50.40)
Sleep quality	6.04 (30.24)	16.41 (36.54)	1.67 (49.86)
Group	345.03 (213.41)		
Pain * Group interaction	93.51 (44.52) *		

Adjusted for gender, age and BMI

*
 $p < 0.05$

TABLE 5

Summary of linear mixed models examining physical activity as a predictor of end of day pain

	Total group, N = 119	Pain group, N = 59	Healthy group, N = 60
	β (SE)	β (SE)	β (SE)
Mean activity			
Physical activity	−0.00 (0.00) *	−0.00 (0.00) *	0.00 (0.00)
Medication use	0.38 (0.13) *	0.50 (0.16) *	0.01 (0.31)
Mood	0.00 (0.05)	0.10 (0.06)	0.08 (0.07)
Sleep quality	−0.10 (0.05) *	−0.10 (0.06)	−0.13 (0.07) *
Group	−5.54 (0.59) *		
Activity * Group interaction	0.00 (0.00) *		
Peak activity			
Physical activity	0.00 (0.00)	−0.00 (0.00)	0.00 (0.00)
Medication use	0.41 (0.13) *	0.52 (0.16) *	−0.02 (0.32)
Mood	0.00 (0.05)	−0.09 (0.06)	0.08 (0.07)
Sleep quality	−0.10 (0.05) *	−0.11 (0.06)	−0.13 (0.07)
Group	−4.58 (0.47) *		
Activity * Group interaction	0.00 (0.00)		

Adjusted for gender, age and BMI

*
 $p \leq 0.05$