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Physical Activity Measured with Accelerometer in Children and Youth with Juvenile Idiopathic Arthritis Compared with Peers in Iceland

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ABSTRACT

Purpose: To compare physical activity in children with juvenile idiopathic arthritis and age-matched peers.

Materials and methods: Daily physical activity was measured for seven consecutive days with activPAL™ accelerometer in 8–18-year-old children with juvenile idiopathic arthritis (n=28) and age- and sex-matched controls (n=35). The main variables were daily steps and duration of time in moderate to vigorous physical activity. A mixed model analysis of variance was used for statistical analysis.

Results: The groups were comparable in terms of age, height, weight, body mass index and sex ratio. There was no difference in physical activity between the groups, measured in daily steps ($p = 0.83$) and duration of time in moderate to vigorous physical activity ($p = 0.92$). Both groups had lower physical activity at weekends than weekdays ($p < 0.001$). No interaction was observed between groups and days of the week regarding daily steps ($p = 0.89$) and time spent in moderate to vigorous physical activity ($p = 0.60$). Neither group met the current physical activity recommendations.

Conclusion: Physical activity of children with juvenile idiopathic arthritis in Iceland is comparable to age-matched peers without juvenile idiopathic arthritis. There is a need for intervention to increase physical activity in both groups.

Keywords: Children, Juvenile idiopathic arthritis (JIA), physical activity

Abbreviations: JIA: juvenile idiopathic arthritis, PA: physical activity, BMI: body mass index, MVPA: moderate to vigorous physical activity, ANOVA: Analysis of variance

Introduction

Juvenile idiopathic arthritis (JIA) is the most common form of chronic arthritis in childhood with an estimated incidence rate of 2–20/100 000. The cause is still poorly understood but includes both genetic and environmental factors.^{1,2} JIA is characterised by recurring episodes of arthritis in one or more joints, often accompanied by pain, morning stiffness, sleep problems, fatigue, decreased muscle strength and difficulty performing activities at home as well as participating in school and other social activities.^{2,3}

The current pharmacological treatment includes both traditional disease-modifying anti-rheumatic drugs as well as newer biologic medicines.⁴ International recommendations and research also address non-pharmacologic interventions including physical therapy.^{5,6} Physical therapists can reduce activity limitations, participation restrictions and ensure quality of life by various methods including activity training, pain-relieving strategies, exercises to increase flexibility, muscle strength and physical activity (PA).⁷

The World Health Organization (WHO) recommendations state that children and young people aged 5–17 years old should do at least 60 minutes of moderate to vigorous intensity physical activity daily (MVPA).⁸ PA is as important for children and adolescents with JIA as for others. Many common symptoms of JIA such as pain, fatigue, sleep disturbance and gait abnormality can negatively affect the children's PA.⁹⁻¹¹

The health benefits of a regular PA in children include improved physical fitness, cardiometabolic health, bone health, cognitive outcomes, mental health, and reduced adiposity.⁸ Regular PA promotes beneficial short- and long-term changes in metabolic, hormonal, and inflammatory pathways.⁸ Changes in these pathways can be favorable for children with JIA. Rochette et al.^{6,12} describe how PA simultaneously induces short-term pro-inflammatory, and short- and long-term anti-inflammatory systemic effects. Regular PA thus seems to modulate pro/anti-inflammatory balance, with the effect depending on duration and intensity of PA/exercise, and on training of the subject. They suggest that future research should aim to find the right trade-off between intensity of the PA/exercise, duration of the exercise, level of training, and exercise-program constraints to obtain the greatest benefits of PA for this group.^{6,12}

Most published studies on the PA of children with JIA have demonstrated lower PA level.¹³ Bos et al.¹⁴

and Fazaa et al.¹⁵ demonstrated that children with JIA had a lower PA level compared to controls using a seven-day activity diary and a questionnaire, respectively. Nørgaard et al.¹⁶ objectively monitored PA in children with JIA compared with healthy controls using accelerometers. Accelerometer counts were lower in the children with JIA than in the controls and PA was negatively correlated with disease activity. However, some studies show contradictory results. Risum et al.¹⁷ used accelerometers for seven days and found no differences in light and moderate PA between children with JIA and healthy controls although the children with JIA spent less time in daily vigorous PA. Interestingly, the use of biological medication was associated with more PA.¹⁷ Various methods to measure PA were used in these studies, both objective including accelerometers, and subjective like activity diaries and questionnaires. Accelerometry is often considered the best option for measuring PA since it reduces recall bias and social-desirability bias as well as having the ability to measure routine activities.¹⁸

Assessment of the children's physical activity is essential for health professionals to be able to promote a physically active lifestyle for children and youth with JIA. The aim of this study was to evaluate PA in children with juvenile idiopathic arthritis (JIA) in Iceland compared to age-equivalent peers and to see if there is a need for an intervention to increase PA.

Material and Methods

DESIGN

The study is a case-control study with a cross-sectional design, and the PA of children is measured directly.

SETTING

The study was a part of a larger research program on children with JIA, conducted in collaboration with the paediatric rheumatology team at the National University Hospital in Iceland.

PARTICIPANTS AND PROCEDURE

Inclusion criteria for children with JIA were: 8-18 years old and registered in the medical record system of the National University Hospital of Iceland, in the years 2016 to 2019, with any subtype of JIA except systemic arthritis. Forty-eight children with JIA were invited.

The control group was a random sample of children aged 8-18 from Registers Iceland. A list of 500 children was obtained from Registers Iceland, of which 249 met the criteria for the study and were invited to participate. Because of difficulties in

recruiting participants, snowball sampling was used in the last stage of the data collection.

The exclusion criteria for both groups were systemic arthritis, co-morbidities which clearly affected mobility, insufficient Icelandic language comprehension of participants and/or their legal guardians, and residency over 100 km from the capital region. The groups were matched in terms of age and sex.

Outcome measures

PA was measured by activPAL4™, a small and lightweight device (23.5mm × 43mm × 5mm and 10 g). It uses an accelerometer to measure body motion which is defined by an energy expenditure classification and a postural classification. It measures time spent sitting/lying, standing, and walking, as well as counting sit-to-stand and stand-to-sit transitions per day. The device allows for calculations on various forms of activity,^{19,20} by also measuring the number of daily steps, step frequency (steps per minute) and metabolic equivalent of task (MET).¹⁹ MET is a physiological measure expressing the intensity of physical activities. One MET is the energy equivalent expended by an individual while seated at rest.⁸ In its standard configuration the activPAL records data every 20th of a second which was used in this study. The data were recorded in 15 second epochs meaning that the occurring events were summarised in each 15 second time slice. Calculations on how many minutes per day were spent in moderate to vigorous PA were based on step frequency. The cut-off point for MVPA was >100 steps per minute.¹⁹

The activPAL's psychometric properties for children have been tested in several studies.^{20,21} The meter is valid for measuring changes in position, sit-to-stand and stand-to-sit transition counts, and step counts at low or average speed in children aged 9-12 years of age.^{20,21} The device does not accurately measure steps taken during fast walking and running.²⁰

The children and their legal guardians also completed activity diaries in this study where they documented hours spent in both organised and unorganised PA.

Procedure

At the first appointment, the accelerometer was placed on the child's thigh. The monitor was worn on the mid- anterior position of the right thigh, 24 hours a day for seven consecutive days. It was attached with a thin transparent film dressing, enclosed in a small waterproof pocket so it could be worn during bathing and swimming. At the second appointment,

the activPAL was removed, height and bodyweight were measured in both groups and body mass index (BMI) calculated. The children with JIA underwent an evaluation of disease activity by a paediatric rheumatologist using the well-established Juvenile Arthritis Disease Activity Score 27 (JADAS-27).²²

The goal was to get a valid measurement of PA on both weekdays and weekend days. The criteria for data analysis were to have the measurements from each participant for a minimum of four weekdays and two weekend days. For a day to be valid, it had to count for measurements of at least ten waking hours. Children can be quite active during the first hours after receiving accelerometers as a reaction to the meters. To avoid measurements of abnormally high activity, the first day was excluded from the data analysis. The last day's measurements were also excluded since they did not cover 10 hours that day. The data from the activity diaries and the objective measurements of PA were compared but data from the diaries were not used for any statistical analysis.

Ethics

The children and parents received verbal and written information, and parents signed an informed consent prior to participating in the study. Children over 12 years also signed the consent. Ethical approval for the study was granted by The National Bioethics Committee (VSN-19-141).

Data analysis

Software included in the activPAL technology and Rstudio (version 1.2.5019, www.rstudio.com) was used to collect data. Data was analysed using Jamovi (version 1.1.9.0, www.jamovi.org). Data from 28 children with JIA (57.1% female) was compared to data from 35 age and sex matched children (54.3% female).

The average of PA on the measured weekdays and weekend days, respectively, was used in the data analysis. Data distribution was described with mean and standard deviation, for continuous variables and n (%) for categorical variables. Level of significance was set at 5%.

The data for daily steps were almost normally distributed. The data for time spent in MVPA were positively skewed requiring a square root transformation to get a normal distribution so that parametric analysis could be used for both variables.

A mixed model ANOVA was used for hypothesis testing. Two separate analyses were performed

where the dependent variables were daily steps, and minutes in MVPA per day. The independent variables were the same for both analyses. Day of the week (weekdays and weekend days) was used as a within-subject variable, and Group (children with JIA and the control group) was used as between-subject variable.

Colley et. al.²³ conducted an analysis of accelerometer and pedometer data collected on 1613 children and youth aged 6–19 years in Canada. They proposed that 12,000 steps per day should be used as a target to determine whether children and youths aged 6–19 year are meeting

the current physical activity guideline of 60 min of daily MVPA. This criterion and the cut-off point for MVPA (step frequency) of the activPAL accelerometers were used to see if the children in the current study met the activity level recommended by WHO.⁸

Results

PARTICIPANTS

A total of 29 children with JIA agreed to participate. One was excluded due to misdiagnosis, resulting in 28 children in the research group, accounting for 58% of the invited participants. Table 1 shows the different subtypes of JIA.

Table 1: Subtypes of JIA

Subtypes	Number (n = 28)	(%)
Oligoarthritis	13	46.4
Rheumatoid factor negative polyarthritis polyarthritis	2	7.1
Rheumatoid factor positive polyarthritis polyarthritis	1	3.5
Enthesitis related arthritis	5	17.9
Psoriatic arthritis	2	7.1
Undifferentiated arthritis	5	17.9

The control group comprised of 35 children, with 29 children selected randomly from the Registers Iceland and nine recruited by the snowball sampling method. The research group and the control group were similar in age, height, weight, BMI and sex

(table 2). Table 2 shows the number of children with joint inflammation and the average JADAS-27 score; a lower JADAS-27 score indicates lower disease activity.²²

Table 2: Characteristics of participants. There were no differences in age, height, weight, BMI and sex in between the research group and the control group

	Children with JIA n =28		Control group (n = 35)	
Sex, girls (%)	16 (57%)		19 (54%)	
	Mean	SD	Mean	SD
Age (years)	12.9	+3	13.1	3.1
Height (cm)	156.5	+13.8	158.8	15.2
Weight (kg)	51.2	+19.2	52.1	13.3
BMI (kg/m ²)	20.2	+4.6	20.3	2.7
JADAS (0-57) (mean score)	2.9 ± 3.1			
Active arthritis*	6 (21%)			

There were no differences in age, height, weight, BMI and sex in between groups.

*Number of children with active arthritis in one or more joints at the time of study inclusion.

Abbreviations: BMI – Body Mass Index, JIA – Juvenile Idiopathic Arthritis, JADAS – Juvenile Arthritis Disease Activity Score.

DAILY STEPS

Figure 1 displays the mean number of daily steps for each group. The children with JIA and their peers showed no difference in mean number of daily steps; $F_{1.58} = 0.05, p = 0.830$. There was a difference in the number of steps between weekdays and weekend days with both groups taking more steps on weekdays than during the weekends; $F_{1.59} = 71.0, p < 0.001$. There was no

significant interaction between groups and days of the week; $F_{1.59} = 0.02, p = 0.894$ (Figure 1). The effects of body height on daily steps were corrected in the analysis; $F_{1.58} = 35.6, p < 0.001$.

Time spent in physical activity of moderate to vigorous intensity

Figure 1 illustrates the mean time spent in MVPA for each group. No difference in mean time spent in

MVPA was observed between children with JIA and their peers; $F_{1,60} = 0.01$, $p = 0.921$ Children in both groups spent more time in MVPA on weekdays than on the weekend days; $F_{1,60} = 57.4$, $p < 0.001$

(figure 1). There was no significant interaction between groups and days of the week in time spent in MVPA; $F_{1,60} = 0.28$, $p = 0.6$.

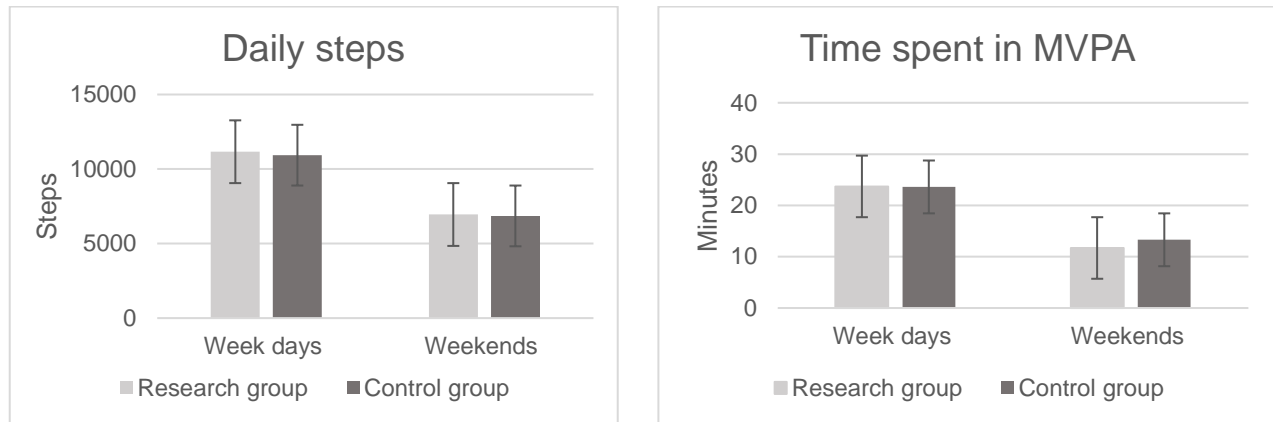


Figure 1. Daily steps and time spent in moderate to vigorous physical activity (MVPA) of both groups on weekdays and during weekends. Values are means with 95% confidence interval. There was a significant difference between weekdays and weekend days in within groups but not between groups.

The children's levels of physical activity compared to the current physical activity guidelines

Based on the cut-off point for MVPA (step frequency) of the activPAL accelerometers and the criteria from Colley et al.²³, neither group in this study met the PA recommendation level, as published by WHO.⁸

Discussion

The main findings of the study were that there was no significant difference in PA between the children with JIA and their peers, measured as the mean number of steps daily and mean time spent in MVPA. In addition, both groups were found to be more active on weekdays than on weekend days, both in terms of mean number of daily steps and mean time spent in MVPA. No significant interaction was found between groups and days of the week, which means that the diagnosis of JIA does not influence the changes in PA (in step counts, time in MVPA) from weekdays to weekend days. Neither group in this study met the PA recommendation level, as published by WHO, for children and youths.

PHYSICAL ACTIVITY

No difference was detected between children with JIA and age-matched peers in number of steps per day, which is consistent with the results from Risum et al.¹⁷ However, Nørgaard et al.¹⁶, Fazaa et al.¹⁵ and Bos et al.¹⁴ reported less PA of children with JIA compared to peers of the same age. The difference in results can be affected by many factors, such as population characteristics, the age

of the children, composition of types of JIA, disease activity and the type of intervention. In the study by Bos et al.¹⁴ the children with JIA had low disease activity and there was no connection between the disease activity and PA whereas Fazaa et al.¹⁵ demonstrated that low PA was inversely related to disease activity. This study as well as the studies from Risum et al.¹⁷ and Nørgaard et al.¹⁶ were all performed in countries with early access to biologic-disease-modifying anti-rheumatic drugs. In this study and the one from Risum, the general level of PA in children with JIA was comparable with age- and sex-matched controls. The PA of children with JIA was lower than in controls in the study from Nørgaard et al.¹⁶ The average JADAS27 score in this study was 2.9 ± 3.1 , which indicates low disease activity and only six children (21.4%) had active arthritis. The children in Risum's study also had a low mean JADAS score¹⁷ while participants in Nørgaard's study had a bit higher JADAS27 mean score and 34% had active arthritis.¹⁶ It is highly likely that the results of these studies reflect children with good access to advanced medical care including early use of biologic disease modifying drugs resulting in low levels of disease activity and active arthritis. The families and children in Iceland meet a paediatric rheumatology team on a regular basis in an organized follow-up care including education about the importance of PA.

Children in both groups were significantly more active on weekdays. Different levels of PA between weekdays and weekend days have not been

demonstrated in other studies of children with JIA. However, this has been demonstrated in a large group of children of primary school age²⁴ and in a study of children with cerebral palsy.²⁵

Children with JIA and their peers did not differ in terms of time spent in MVPA per day, which is partially consistent with the results of Risum et al. showing no difference in moderate PA but they found difference between groups in vigorous activity.¹⁷

Based on the cut-off point for MVPA (step frequency) of the activPAL accelerometers and the criteria from Colley et al.,²³ neither group in this study met the PA recommendation level, as published by WHO, for children and youths on weekdays.⁸ The difference was even more striking during the more sedentary weekend days. This is consistent with a study by Magnússon et al.²⁶ showing that a low proportion of healthy children in Iceland reached the minimal amount of MVPA.

Low PA levels developed in youth are likely to persist in adulthood, resulting in a sedentary lifestyle. The potential risk of morbidity later in life is inversely correlated with PA. The benefits of PA are effective at a young age but can also serve to reduce morbidity in later life. Ongoing, habitual PA promotes good physical and mental health.²⁷ A significant number of children with JIA enter adulthood with an active disease,²⁸ so high PA level from childhood is important to lower the risk of other chronic diseases in addition to the arthritis.

The results of the study identify targets for physical therapy management. There is a need to encourage PA level in both groups.

Physical activity for children with juvenile idiopathic arthritis

Physical therapists have the knowledge and skills to supervise interventions that promote safe exercise and physical fitness in children with JIA to increase or maintain their PA level. Physical therapists should be a part of each paediatric rheumatology team and involved in the education of the children and their families. They should address the importance and benefits of PA, the amount of PA and introduce activities suiting each child's age and interest, taking into account individual and environmental circumstances.

Evidence demonstrates that it is safe, feasible, and acceptable for children with JIA to participate in PA. The results from two recent systematic reviews on the efficiency of exercises for children with JIA showed some benefits of exercise, including

decreased pain, increased muscle strength and stamina, better flexibility, improved daily activities, and better quality of life. The exercises appeared to be well tolerated, without adverse events^{29,30}. The authors of these two papers and Cavallo et al.³¹ in their clinical guidelines for PA agreed that the type of exercise should be carefully selected and that high-impact activities could not be recommended for this population due to a lack of evidence.

However, some researchers have emphasized the significance of weight-bearing physical activities and muscle strengthening exercises for optimal bone mass and strength building for children. In their studies children with JIA participated in an exercise program that incorporated short bouts of high-impact exercise involving jumping and resistance training. The results suggested that children with low disease activity can participate in exercise sessions including high-impact activities.³²

STRENGTHS AND LIMITATIONS

This is the first study of the PA of children with JIA in Iceland. The population approach, the participation of 58% of the children with JIA within the capital area without reimbursement and the fact that the follow-up program at the National University Hospital includes almost all children with JIA in Iceland indicate that the findings from this study can be applied to the population of children with JIA. Most of the children in the control group were randomly selected from Registers Iceland so the sample is likely to be representative of the population. The groups were similar in age, sex, height, weight, BMI and group size, which avoids bias.

The measurement of PA was objective, and thus gave a better insight into everyday movements than subjective measures such as questionnaires and PA diaries.¹⁸ The activPAL measurement units have the advantage of being thin and small and are not removed from the thigh during bathing. The data used were from measurements on four weekdays and two weekend days, which is believed to represent the variety of PA seen over an ordinary week.

The study has several limitations. This was a cross-sectional observational study; therefore, no causal inferences can be made. The study may be prone to non-participation bias, with participants potentially having more interest in health and PA than non-participants, something that could be more evident among the oldest children. The researchers contacted the legal guardians to invite their children to participate in the study, and the parents' interest

in PA could also have biased the selection. Generalization to other groups, therefore, must be handled carefully.

Due to a small population in Iceland the sample of children with JIA was small even though almost 50% of all the children aged 8-18 years with the diagnosis of JIA in the medical record system of the hospital participated. The research group was a convenience sample. Only children from the capital area and vicinity were invited. The JIA team at the National University Hospital in Iceland serves almost all children with JIA in the country. The follow-up was similar for the whole group. Therefore, to omit the children from other areas of the country should not have impacted the results. Due to the small sample size, it was not possible to compare PA between children with an active and inactive disease or between JIA subtypes.

Conclusions

Children with JIA demonstrated similar PA as their peers measured as the mean number of daily steps, and mean time spent in MVPA. Both groups were

more active on weekdays. Neither group met the levels of PA recommended for children and youths by WHO. Physical therapists can supervise safe interventions to increase the PA level in children with JIA.

This study may be one of the first to indicate increasing capabilities for PA in children with JIA within the new treatment era. Increased capability makes it easier for physical therapist and each child to work towards higher PA level and thereby lower the risk of other chronic diseases in adulthood.

Conflicts of interest: None declared

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