



Adults with congenital heart disease overestimate their physical activity level

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ARTICLE INFO

Article history:

Received 4 April 2018

Received in revised form 5 November 2018

Accepted 8 November 2018

Available online 17 November 2018

Keywords:

Adult congenital heart disease

Physical activity level

IPAQ

Actiheart

ABSTRACT

Background: Physical activity reduces the risk of acquired cardiovascular disease, which is of great importance in patients with congenital heart disease (CHD). There are diverging data whether physical activity level (PAL) differs between patients with CHD and controls. Furthermore, it is unknown if PAL can be reliably assessed in patients with CHD using self-reported instruments.

Methods: Seventy-five patients with CHD (mean age 37.5 ± 15.5 years, women $n = 29$ [38.7%]) and 42 age and sex matched controls completed the International Physical Activity Questionnaire (IPAQ) and carried the activity monitor Actiheart over 4 days. Time spent at ≥ 3 METS ≥ 21.4 min/day, i.e. reaching the WHO recommendation for PAL to promote health, was used as the outcome measure. Data on PAL obtained from IPAQ were compared with Actiheart.

Results: The proportion of individuals reaching target PAL according to IPAQ was similar in patients with CHD and controls (70.7%vs.76.2%, $p = 0.52$) as well as between patients with simple and complex lesions. There was an overall difference between IPAQ and Actiheart in detecting recommended PAL (72.6%vs.51.3%, $p < 0.001$). In a subgroup analysis, this difference was also detected in patients but was borderline for controls. The negative predictive value for IPAQ in detecting insufficient PAL was higher in patients than in controls (73%vs.40%).

Conclusions: The proportion of persons reaching sufficient PAL to promote health was similar in patients and controls. The self-reported instrument overestimated PAL in relation to objective measurements. However, with a high negative predictive value, IPAQ is a potentially useful tool for detecting patients with insufficient PAL.

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1. Introduction

Physical activity reduces the risk of future disease including common diseases like atherosclerosis and cancer [1–3]. Furthermore, physical activity is an important therapeutic option in highly prevalent conditions such as diabetes and hypertension and during cardiac rehabilitation. The current recommendation of the World Health Organization (WHO), for adults aged 18–64, to preserve/promote health is at least 150 min of moderate physical activity per week (21.4 min per day), i.e. ≥ 3 metabolic equivalents (METs) or at least 75 min of vigorous-intensity physical activity per week or an equivalent combination of both [4]. Approximately 50% in the general population are sufficiently active to reach recommended activity level [5,6].

In contrast to acquired cardiovascular disease, congenital heart disease (CHD) affects the individual from birth. On group level, most adults with CHD have impaired aerobic capacity. However, this is compatible in most cases with performing daily activities [7,8]. There are controversies on physical activity level (PAL) in adult patients with CHD. We [5] and others [9,10] have shown that adult patients with CHD are equally active compared with controls. Furthermore, similar results were reported in children with CHD [11,12] which also is the most commonly studied group. Therefore, our study focuses on the much less studied adults with congenital heart disease.

The presence of CHD with 'low grade' residual lesions and previous cardiac interventions are urgent reasons to prevent additional acquired heart disease. Addition of acquired heart disease in these patients may have severe consequences. At present, there is no clear evidence or guidelines on how to handle primary prevention and risk factor intervention for this population. In addition, advice on physical activity should be individualized and possible risks should be considered [13]. However, promoting physical activity is a general action that can be widely applied in many situations. From this perspective, it is more important to identify patients that are insufficiently active rather than

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¹ This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

those that are reaching recommended activity level. Therefore, there is a need for reliable and clinically applicable screening tools.

PAL can be assessed by patient history, self-reported instruments and objective measurements with the latter being the most reliable. The clinical use of objective methods is relatively complicated and expensive, whereas self-reported instruments are cheap and can easily be incorporated into clinic routines. It is currently unknown if PAL can be reliably assessed in patients with CHD using self-reported instruments. The aim of the present study was to compare self-reported physical activity assessed by IPAQ with objectively obtained data from the activity monitor Actiheart. In addition, we explore to what extent adults with CHD reach recommended PAL using the International Physical Activity Questionnaire (IPAQ).

2. Methods

2.1. Patients

Adult patients with CHD were recruited from the specialized adult CHD units in two cities in Sweden – Umeå and Lund. Inclusion criteria were periodic out-patient medical visits for CHD and a clinically stable condition over the past three months. Exclusion criteria were cognitive impairment affecting independent decision-making, extra-cardiac disease affecting physical activity or other circumstances making participation unsuitable, e.g. inconvenience wearing the Actiheart monitor. One hundred and thirteen patients were asked to participate. Twenty-three (20.4%) declined participation and five did not come to the clinical appointment. Thus, 85 patients were included for the study, of these 75 had both Actiheart registration and IPAQ data. To achieve a balanced diversity of diagnoses and complexities, since simple lesions are much more common, patients were recruited into the following four groups based on diagnosis: (I) shunt lesions, (II) left-sided lesions, (III) tetralogy of Fallot, pulmonary atresia or transposition of the great arteries, and (IV) secondary pulmonary hypertension (Eisenmenger physiology), patients palliated with Fontan operation or total cavo-pulmonary connection (TCPC), or other complex lesions. Recruitment continued until each group was filled with at least 20 patients. Groups (I) + (II) were classed as 'simple', and Groups (III) + (IV) as 'complex' (Table 1); such grouping was in accordance with a classification previously used by others [14], and it harmonizes with the expected exercise capacity [7]. One hundred twenty-nine age and gender matched individuals (73 men, 56 women) living in the Umeå area were randomly selected from the national population register, contacted via phone, and asked to participate as controls. Eighty-six (66.7%) persons declined participation (47 men, 39 women) and one person did not show up at the clinical appointment. This resulted in 42 matched controls (i.e. no

CHD or any exclusion criteria presented above) being included for the study. Participants and those who declined participation/did not show up at the clinic appointment differed with respect to age (37.5 ± 15.5 vs. 31.1 ± 11.8 , $p = 0.03$) but not regarding sex ($p = 0.54$) or complexity of heart lesion ($p = 0.25$). Descriptive data of included patients and controls are presented in Table 2. Prior to participation, patients and controls gave their written informed consent. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki and was approved by the regional Ethics Review Board (Dnr 2011-51-31 M).

2.2. Activity monitoring

Habitual physical activity was objectively assessed by using Actiheart (CamNTEC, Ltd., Cambridge, UK), a combined heart rate monitor and uniaxial accelerometer. The monitor was applied on the left side of the chest and carried day and night for four consecutive days. The participants were instructed to continue with their habitual activities. Time spent at moderate-to-vigorous physical activity (≥ 3 MET) was analyzed. Further details of the activity monitoring and analysis of time spent at moderate-to-vigorous physical activity (≥ 3 MET) are described in detail elsewhere [5]. The Actiheart monitor has previously been validated [15,16].

2.3. IPAQ

All participants completed the long version of the IPAQ [17] in the end of the Actiheart monitoring period in order to cover the same period of time. The IPAQ is a 7-day recall questionnaire that measures time spent per week on vigorous activity, moderate activity and walking. The instrument has been validated in a number of countries including Sweden [18]. The total time spent at or above moderate-to-vigorous physical activity was calculated and dichotomized into reaching or not reaching current recommendations on PAL, i.e. 150 min per week of moderate activity.

2.4. Statistics

Data were assessed for normality. Results are presented as means $\pm$ standard deviations. Differences between groups were tested with Student's independent samples *t*-test for means and chi-squared test for ratios. Associations between IPAQ and Actiheart were tested with McNemar's test for paired proportions using chi-squared test. In post-hoc power analysis, the study has power to detect medium size effect size in the total cohort and among patients and a large effect size among controls. Sensitivity, specificity, positive predictive value and negative predictive value were calculated for reaching sufficient PAL with Actiheart as reference method. All calculations were performed in SPSS 23 (IBM, Armonk, NY, USA). The null hypothesis was rejected at p -values < 0.05 .

3. Results

The controls had higher body weight and less medications than the CHD patients. Patients with complex lesions had lower body weight and more medication compared with controls. There were no other differences between controls and patients (Table 2).

There was no difference between patients and controls (70.7 vs. 76.2%, $p = 0.52$) or between patients with simple and complex lesions (76.9 vs. 63.9%, $p = 0.22$) in the proportion that reached recommended PAL according to IPAQ (Table 2). There was no difference between patients and controls (48.0 vs. 57.1%, $p = 0.34$) or between patients with simple and complex lesions (53.8 vs. 41.7%, $p = 0.29$) in the proportion that reached recommended PAL according to objectively measured activity with Actiheart (Table 2).

A higher proportion of all subjects (72.6 vs. 51.3%, $p < 0.001$) reached recommended PAL according to IPAQ compared with Actiheart. In

Table 1
Distribution (with number of patients) of congenital heart lesions and classification into simple vs. complex lesions.

Simple lesions		Complex lesions	
VSD	14	d-TGA	4
ASD	1	ccTGA	2
PDA	1	ToF	8
PFO	1	PA	1
CoA	11	DORV	2
AS	3	DILV (no intervention)	1
AR	3	TCPC	6
AS/AR	4	Fontan	2
MR	1	Ebstein	3
		Eisenmenger	6
		Miscellaneous	1

Data are presented as n, number. VSD, ventricular septal defect; ASD, atrial septal defect; PDA, persistent ductus arteriosus; PFO, persistent foramen ovale; CoA, coarctation of the aorta; AS, aortic stenosis; AR, aortic regurgitation; MR, mitral regurgitation; d-TGA, d-transposition of the great arteries; ccTGA, congenitally corrected transposition of the great arteries; ToF, tetralogy of Fallot; PA, pulmonary atresia; DORV, double outlet of right ventricle; DILV, double inlet left ventricle; TCPC, total cavo-pulmonary connection.

Table 2
Descriptive data of the control group and patients with congenital heart disease.

		Control group (n = 42)	CHD (n = 75)	p	Subgroup analysis	Simple lesions (n = 39)	Complex lesions (n = 36)	p
Sex female	n (%)	16 (38.1)	29 (38.7)	0.95 ^a		15 (38.5)	14 (38.9)	0.97 ^b
Age years	mean ± SD	36.9 ± 14.9	37.5 ± 15.5	0.83 ^a		35.0 ± 13.9	40.3 ± 16.9	0.14 ^b
Height m	mean ± SD	1.76 ± 0.09	1.73 ± 0.09	0.14 ^a		1.73 ± 0.09	1.73 ± 0.1	0.65 ^b
Weight kg	mean ± SD	79.5 ± 16.5	73.2 ± 15.5	0.04 ^{a,*}	0.35 ^c 0.01 ^{d,**}	76.1 ± 16.4	70.2 ± 14.1	0.10 ^b
BMI kg/m ²	mean ± SD	25.8 ± 5.3	24.4 ± 4.3	0.12 ^a		25.1 ± 4.4	23.5 ± 4.1	0.10 ^b
Smoking								
Non-smoker	n (%)	37 (88.1)	63 (84.0)	0.6 ^a		30 (76.9)	33 (91.7)	0.15 ^b
Active smoker	n (%)	4 (9.5)	7 (9.3)			6 (15.4)	1 (2.8)	
Previous smoker	n (%)	1 (2.4)	5 (6.7)			3 (7.7)	2 (5.6)	
Cardiovascular medication yes	n (%)	8 (19.0)	37 (49.3)	0.001 ^{a,***}	0.22 ^c <0.001 ^{d,***}	12 (30.8)	25 (69.4)	0.001 ^{b,***}
SBP mmHg	mean ± SD	na	128 ± 21	na		134 ± 21	123 ± 20	0.03 ^{b,*}
DBP mmHg	mean ± SD	na	75 ± 11	na		75 ± 11	75 ± 10	0.45 ^b
NYHA class								
I	n (%)	na	53 (70.7)	na		38 (97.4)	15 (41.7)	<0.001 ^{b,***}
II	n (%)	na	12 (16.0)			1 (2.6)	11 (30.6)	
III	n (%)	na	10 (13.3)			0 (0)	10 (27.8)	
IV	n (%)	na	0 (0)			0 (0)	0 (0)	
Previous intervention yes	n (%)	na	41 (54.7)	na		16 (41.0)	25 (69.4)	0.01 ^{b,**}
Age at intervention years	median (IQR)	na	5.0 (3.0–18.0)	na		12.0 (4.0–25.5)	4.5 (2.0–11.0)	0.22 ^b
Previous interventions number of	median (IQR)	na	1 (0–2)	na		0 (0–1)	1 (0–3)	0.001 ^{b,***}
Device								
PM	n (%)	na	2 (2.7)	na		1 (2.6)	1 (2.8)	0.33 ^b
ICD	n (%)	na	2 (2.7)			0 (0)	2 (5.6)	
Reaching recommended PAL (IPAQ) yes	n (%)	32 (76.2)	53 (70.7)	0.52 ^a		30 (76.9)	23 (63.9)	0.22 ^b
Reaching recommended PAL (Actiheart) yes	n (%)	24 (57.1)	36 (48.0)	0.34 ^a		21 (53.8)	15 (41.7)	0.29 ^b

CHD, congenital heart disease; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; NYHA, New York Heart Association; PM, pacemaker; ICD, implantable cardioverter defibrillator; IPAQ, international physical activity questionnaire. a) Comparison between control group and CHD. b) Comparison between patients with simple and complex lesions. c) Comparison between control group and patients with simple lesions. d) Comparison between control group and patients with complex lesions. Bold text indicates significant levels.

* $p < 0.05$.

** $p < 0.01$.

*** $p \leq 0.001$.

Table 3
Number of subjects reaching recommended PAL according to WHO guidelines assessed by IPAQ and by Actiheart.

a)			
CHD + controls			
	Reaching PAL, Actiheart		
Reaching PAL, IPAQ	Yes	No	Total
Yes	48 (56.5)	37 (43.5)	85 (100)
No	12 (37.5)	20 (62.5)	32 (100)
Total	60 (51.3)	57 (48.7)	117 (100)

$p < 0.001$ for McNemar's test for paired proportions.

b)			
CHD			
	Reaching PAL, Actiheart		
Reaching PAL, IPAQ	Yes	No	Total
Yes	30 (56.6)	23 (43.4)	53 (100)
No	6 (27.3)	16 (72.7)	22 (100)
Total	36 (48.0)	39 (52.0)	75 (100)

$p = 0.002$ for McNemar's test for paired proportions.

c)			
Controls			
	Reaching PAL, Actiheart		
Reaching PAL, IPAQ	Yes	No	Total
Yes	18 (56.3)	14 (43.8)	32 (100)
No	6 (60.0)	4 (40.0)	10 (100)
Total	24 (57.1)	18 (42.9)	42 (100)

$p = 0.12$ for McNemar's test for paired proportions.

Data are presented as numbers (%). CHD, congenital heart disease; IPAQ, International Physical Activity Questionnaire; PAL, physical activity level.

a subgroup analysis, this difference was also detected in patients with CHD (70.7 vs. 48.0%, $p = 0.002$) and with similar proportions for controls (76.2 vs. 57.1%, $p = 0.12$) but not reaching significance (Table 3 a–c). Patients that reached recommended PAL according to IPAQ, but not Actiheart, did not differ from those with agreement between the two methods regarding age ($p = 0.85$), sex ($p = 0.11$), BMI ($p = 0.17$), NYHA class ($p = 0.73$), or disease complexity ($p = 0.98$). The output from Actiheart and IPAQ, as continuous variables, was assessed in correlation analysis using the Spearman method ($r = 0.2$, $p = 0.02$).

With Actiheart as a reference method, the sensitivity and positive predictive value for IPAQ in detecting sufficient PAL was equal for the total population (CHD + controls), CHD and controls (75–83% and 56–57% respectively). The specificity was higher in CHD compared with controls, 41 vs. 22%. The negative predictive value was also higher for CHD compared with controls, 73 vs. 40% (Table 4).

4. Discussion

Using both objective and self-reported measurements, we report that adults with CHD reached the recommended PAL to the same extent

Table 4
Sensitivity, specificity, positive predictive value, and negative predictive value for IPAQ with Actiheart as a reference method.

	CHD + controls	CHD	Controls
Sensitivity	80	83	75
Specificity	35	41	22
Positive predictive value	56	57	56
Negative predictive value	63	73	40

Data are presented as percent. IPAQ, International Physical Activity Questionnaire; CHD, congenital heart disease.

as their healthy peers. However, subjective measurements appear to have a lower threshold, i.e. a higher proportion reached recommendations assessed by IPAQ compared to Actiheart when considering the complete study cohort. In a subgroup analysis, this difference was also seen among patients and with similar proportions but not reaching significance for controls. Thus, we conclude that both patients and controls overestimate their self-reported PAL relative to objective measurements.

It is unclear why persons overestimate their PAL in relation to objective measurements. In general, self-reported instruments suffer from social desirability bias and recall bias that hampers the liability. Patients with CHD use a higher proportion of their physical capacity in daily activities [7]. Although speculative, this may contribute to the overestimation of their PAL. Analogous overestimations have been reported in the general population regarding physical activity [19] and in adults with CHD regarding physical capacity [20] and quality of life [21]. However, self-reported quality of life is strongly associated with PAL in adults with CHD [22]. The risk of overestimation using self-reported instruments is important to be aware of for all health professionals caring for adults with CHD.

In clinical practice, it is more important to identify those with insufficient PAL rather than those with high PAL. Extrapolated from our data, 20–30% of patients overestimated their PAL in relation to objective measurements. This is clearly a group that is hard to identify, especially since they do not differ from other patients regarding the variables examined in our study. The logical solution would be to perform objective measurement of PAL; however, with the current available monitors this appears impractical and expensive. Future technical solutions (e.g. mobile applications) may overcome these obstacles and development of such devices should be encouraged. Self-reported data obtained from IPAQ may in any case be used to identify some of the patients with low PAL, and can therefore still be a useful tool in clinical practice. This is supported by the fairly good negative predictive value, 73%, for detecting patients with low PAL in the cohort of patients with congenital heart disease.

In the present study, we show that there is no within-modality difference in PAL between patients and controls, or between patients with simple and complex lesions. This is also in agreement with previous reports [12]. It is important to note that we measure overall PAL. Therefore, regular exercise training of high intensity for a relatively short period of time may yield the same output as low intensity activity performed over a longer period of time. It may be that such mechanisms actually reduce possible differences in intensity of physical activity between groups.

4.1. Limitations

The sample size in our study is relatively small and based on a population with mixed CHDs. However, we include age and sex matched controls randomly selected from the general population. Furthermore, a mixed variation of congenital heart lesions makes the data more generalizable. Self-reported instruments, when applied on activities during the last week, may suffer from recall bias. On the other hand, this applies for both cases and controls. Moreover, IPAQ is a validated and established instrument for self-assessed PAL.

There was a clear significant difference between reaching sufficient PAL using IPAQ versus Actiheart in the total population ($n = 117$) and among patients ($n = 75$). However, among controls ($n = 42$) the test did not reach statistical significance, but the percentages were similar. Therefore, we consider this latter test as underpowered and still conclude that IPAQ overestimated PAL in all studied groups in relation to Actiheart.

The time covered by IPAQ and the Actiheart monitor differs due to limited battery time (4 days) of the accelerometer which might affect the differences found. However, in a previous analysis of potential differences between patient and controls regarding period of measurement

(weekdays vs weekends) using the Actiheart no differences were found [5].

5. Conclusions

In conclusion, the proportion of persons reaching sufficient PAL to promote health was similar in patients and controls. The self-reported instrument overestimated PAL in relation to the objective measurement in both patients and controls. This may have implications on how patients' information regarding PAL should be interpreted. Self-reported instruments for assessment of PAL can be used in the clinical setting, but based on our data they are primarily useful to detect patients with a low PAL.

Funding

The work was supported by the Swedish Heart and Lung Foundation [grant numbers 20130472, 20150579]; the Heart Foundation of Northern Sweden; Umeå University; and the County Council of Västerbotten.

Conflict of interest

The authors do not have any conflicts of interest associated with this work.

Acknowledgements

The authors thank Professor Tommy Olsson and his research team at Public Health and Clinical Medicine for lending us their Actiheart monitors. We are also grateful for the knowledge on using the Actiheart monitors that was generously provided by Anna Gradmark. The authors also thank Margot Johansson and Lars Arén for help with recruitment of control participants.

Authors' Contributions

BJ, KW and CS designed this study. BJ, KW, UT and CS collected data. LL, BJ and CS analyzed the data. All authors wrote and critically revised the manuscript and approved the final article.

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