OPEN ACCESS
Freely Available Online

JOURNAL OF HYPERTENSION AND CARDIOLOGY
ISSN NO: 2329-9487

Research Article

DOI : 10.14302/issn.2329-9487.jhc-17-1493

Single Daily Activity or Exercise Capacity Measurements Did not Predict Future Changes in Cardiovascular Risk Factors in Congenital Heart Disease

Jan Müller[1,2], Pia von Korn[2], Nils Olson[2], Eva Nuspl[2], Julia Hock[2], Peter Ewert[1], Renate Oberhoffer[1,2], Alfred Hager[1]

1. Department of Pediatric Cardiology and Congenital Heart Disease, Deutsches Herzzentrum München, Technische Universität München
2. Institute of Preventive Pediatrics, Technische Universität München

Abstract

Objective: Studies suggest that cardiovascular risk of patients with congenital heart disease (CHD) is increased. This study aims on the predictive value of a single daily activity and exercise capacity assessments on the change of body-mass-index (BMI) and blood pressure in the future.

Patients and Methods: We retrospectively analyzed all patients with CHD who underwent a daily activity assessment by triaxial accelerometry and accompanied cardiopulmonary exercise testing. From 276 patients 16 years or older (120 female, 28.6 ± 8.5 years) current BMI and blood pressure could be abstracted from their last outpatient visit.

Results: After a mean follow-up of 5.5 ± 1.5 years, the BMI of the patients has increased from 23.0 ± 3.4 to 23.7 ± 3.5 kg/m^2 (p<.001) corresponding to an annual increase of 0.14 ± 0.40 kg/m^2 respectively. The systolic blood pressure decreased by -0.37 ± 3.14 mmHg (p=.049).

The multivariable regression analysis corrected for confounders showed no association to annual BMI change according to baseline daily activity levels (p=.891) or peak oxygen uptake (p=.596). Only in patients with higher BMI at baseline (Beta= -.275; p<.001) and females (Beta= -.177; p=.009) increase in BMI was less. Also the blood pressure change was not associated with daily activity levels (p=.420) and peak oxygen uptake (p=.732) at baseline.

Conclusions: Single daily activity or exercise capacity measures do not predict future BMI or blood pressure changes. Regular evaluation of functional status including exercise testing, activity assessment and tailored counseling are therefore recommended in patients with CHD.

Corresponding Author:

Jan Müller, Department of Pediatric Cardiology and Congenital Heart Disease, Deutsches Herzzentrum München, Technische Universität München, Lazarettstr. 36, D-80636 München, Germany, Phone: +49-89-1218-3009, Fax: +49-89-1218-3003, Email: j.mueller@tum.de

Keywords: activity – prevention –exercise testing - congenital

Received Mar 21, 2017; **Accepted** Apr 19, 2017; **Published** Jun 05, 2017;

Introduction

Due to improvements in cardiac surgery, life expectancy of patients with congenital heart disease (CHD) has increased over the past decades with almost up to 85% of the children with CHD reaching adulthood.[1,2] But living longer also means that those patients will face the burden of acquired cardiovascular diseases changing medical aftercare, which has now to focus also on cardiovascular risk factors than congenital cardiac issues alone.[3-5] Therefore, it is important to identify risk factors that predict classic cardiovascular endpoints such as myocardial infarctions, stroke or sudden cardiac death.

Several reports have clearly underpinned the beneficial effects of daily exercise on several health outcomes and it is widely accepted, that an active lifestyle of at least 30 minutes daily activity on five or even all days of the week lowers cardiovascular risk in adults.[6] But older generations of patients with CHD were raised with the notion that physical exercise has cardiac side effects. Leading, at worst case, even to sudden cardiac death. However, recent guidelines promote now physical activity and emphasize the importance of physical activity regarding cardiovascular health also for patients with CHD.[7-9]

Peak oxygen uptake is an important parameter used for evaluating the prognosis of patients with CHD and making clinical decisions.[10-13] The fact that peak oxygen uptake is associated with regular activity shows the need for participation in physical activities and leisure sports among adults with CHD.[7,8,14,15]

The aim of this study was to assess the predictive value of a single physical activity and exercise capacity assessment on the change of two major cardiovascular risk factors body-mass-index (BMI) and blood pressure in the short- and mid-term future.

Patients and Methods

Study subjects and Follow-up analysis

We included all patients with CHD who underwent a cardiopulmonary exercise test (CPET) and an additional assessment of their physical activity level by triaxial accelerometry from October 2007 to January 2010 as part of their routine follow-up examination in our institution. The study protocol was approved by the local ethical board (project number 1931/07). Almost all of the patient's data regarding the association of exercise capacity and physical activity was previously published.[15]

From 276 patients 16 years or older (120 female, 28.6 ± 8.5 years) current BMI, systolic blood pressure and hypertensive therapy could be extracted from their last outpatient visit. In 29 (12.7%) patients hypertensive therapy was intensified whereas in 16 (7.0%) a reduction was noted. In the major part of the cohort (80.3%) there was no or unchanged medical treatment at follow-up

Methods performed at baseline testing

Baseline data was acquired in our institution from October 2007 to January 2010 from routine CPET testing. First, all patients performed a symptom-limited CPET on a bicycle in upright position on a rampwise protocol as previously reported.[16] Peak oxygen uptake (VO_2 peak) was defined as the highest mean uptake of any 30sec. time interval during exercise. Reference values for age, body mass, body height and gender, expressed in "% predicted" were calculated as previously described[16].

After CPET daily physical activity was measured by the triaxial accelerometer RT3 (Stay-healthy, Monrovia, CA, USA) which represents the gold standard of daily activity measurement.[15] The accelerometer was worn on the waist for the next seven consecutive days and was only removed during swimming, showering, and bedtime. We used vector magnitudes calculated from the three dimensions with a sampling epoch of 1 minute. Daily activity was defined as the mean activity units of these seven days. The daily minutes in moderate (3-6 MET) and vigorous activity (>6 MET) were calculated, using the published cut-off-points for moderate (>984 counts/min) and vigorous (>2.340 counts/min) activity in adults [17]. For our statistical analysis pooled data from moderate to vigorous activity representing all activity >3 MET were used.

Table 1: Patients characteristics

	Study Group
Sex (female / male)	120 / 156
Age (years)	28.6 ± 8.5
BMI (kg/m^2)	23.0 ± 3.4
Peak oxygen uptake (ml/min/kg)	26.5 ± 7.8
Peak oxygen uptake (%predicted)	74.7 ± 18.6
Daily activity# (min/day)	61.1 ± 39.4
Moderate activity (min/day)	52.8 ± 33.2
Vigorous Activity (min/day)	8.3 ± 10.4
Met daily activity Recommendations (%)	76.1

#Pooled data from moderate to vigorous activity representing all activity >3 MET

Data analyses

All descriptive data was expressed as mean ± standard deviation. Change in BMI and systolic blood pressure were corrected for follow-up length by converting into an annual reduction or increase. Annual reduction rate was tested for significance using a one sample t-test versus zero.

Multivariable linear regression was used to examine a possible influence of daily activity and exercise capacity on the annual BMI or blood pressure change. Age, sex and BMI or systolic blood pressure at baseline were included as covariates into the statistic model. For blood pressure prediction analysis it was also taken into account if the hypertensive treatment changes during follow-up. After testing daily activity and exercise capacity independently with annual BMI or blood pressure change they were tested again in a combined model against each other.

For all analyses, a probability value of $p<0.05$ was considered to be statistically significant. All analyses were performed using SPSS 23.0 software (IBM INC, Armonk, New York, USA).

Results

Patient's baseline characteristics are displayed in table 1. After a mean follow-up of 5.5 ± 1.5 years, the BMI of the patients has increased slightly from 23.0 ± 3.4 to 23.7 ± 3.5 kg/m^2 corresponding to an annual increase of 0.14 ± 0.40 kg/m^2 ($p<.001$) respectively. The systolic blood pressure remained stable at 123.3 ± 13.7 to 122.2 ± 13.5 mmHg with an annual reduction rate of -0.37 ± 3.14 mmHg ($p=.049$).

The multivariable regression analysis corrected for age, sex and baseline BMI showed no association to BMI change per year according to daily activity levels ($p=.891$) and peak oxygen uptake ($p=.596$). That holds also true if combining both parameters in one regression model (Table 2). Splitting daily activity off into moderate and vigorous components does not provide a merit to the analysis. Patients with higher BMI at baseline (Beta= -.275; $p<.001$) and female sex (Beta= -.177; $p=.009$) has less increase in annual BMI (Table 2).

The multivariable regression analysis corrected for age, sex, baseline systolic blood pressure and changes in hypertensive treatment throughout follow-up also showed no effect on the annual systolic blood pressure change with regard to daily activity levels ($p=.259$) and peak oxygen uptake ($p=.540$) in the univariate model.

Table 2: Multivariable linear regression model to predict Body Mass Index change per year in patients with congenital heart disease.

Variable	Regression Coefficient	SE	Beta	p-value
Age (years)	-0.002	.003	-.034	.600
BMI at Baseline (kg/m^2)	-0.032	.008	-.275	**<.001**
Sex (0=male, 1=female)	-0.143	.054	-.177	**.009**
Peak oxygen uptake (ml/min/kg)	0.002	.004	.036	.629
Daily activity* (min/day)	0.001	.001	.019	.811

*Pooled data from moderate to vigorous activity representing all activity >3 MET, BMI: Body Mass Index, SE=Standard error

Patients with higher blood pressure at baseline were measured with lower blood pressure (Beta= -.250; p<.001) at follow-up (Table 3).Moreover, patients who had a reduction in their hypertensive treatment had an increase of resting systolic blood pressure of about one mmHg and those with an increase in hypertensive drugs a reduction of almost one mmHg (Table 3).

Discussion

This study could not find an association of a single measurement of daily activity or exercise capacity to short- or mid-term BMI or blood pressure change in patients with CHD.

In general there was a moderate increase in BMI in our group during follow-up, a phenomenon that is normal in that age group [18] and most prominent in slender males. But it was not possible to associate daily activity or exercise capacity from the baseline test with that increase in our investigated follow-up. Thus no conclusion could be drawn whether exercise capacity or daily activity provide better prognostic value for changes in BMI. However, the analysis suggest that more attention on these issues should be payed to males.

Systolic blood pressure remains stable throughout follow-up because hypertensive treatment was adjusted in almost 20% of the patients. But also taking the issue of medical treatment change into account, no prediction of systolic blood pressure was possible from daily activity or exercise capacity at

Table 3: Multivariable linear regression model to predict systolic blood pressure change per year in patients with congenital heart disease.

Variable	Regression Coefficient	SE	Beta	p-value
Age (years)	0.004	.024	.012	.855
Systolic Blood Pressure at Baseline (mmHg)	-0.057	.014	-.250	**<.001**
Sex (0=male, 1=female)	-0.758	.422	-.120	.074
Change in Medication (-1=reduction, 0 no change, +1 increase)	-0.815	.453	-.106	**.033**
Peak oxygen uptake (ml/min/kg)	0.008	.029	.021	.778
Daily activity* (min/day)	0.005	.005	.064	.324

*Pooled data from moderate to vigorous activity representing all activity >3 MET
BMI: Body Mass Index, SE=Standard error

baseline. Moreover, the fact that higher blood pressure at baseline was a predictor for a blood pressure decrease suggests either appropriate treatment adjustment or simply regression to the mean.

In general measures of physical fitness and physical activity have shown a robust outcome regarding survival in the general population[19-22] and exercise capacity also in patients with CHD on long term.[10-12] Both also yield significance for softer end-points in the normal population[23-26] and the development of hypertension in patients with coarctation of the aorta.[13]

In a study from Stefan and colleagues[27] in children with CHD activity restriction and exercise intolerance were the strongest predictor for risk of overweight and obesity at follow-up. Also Tikkanen et al.[28] observed an association between frequent daily activity and BMI loss. However, both studies lacked the methodological gold standard measurement for their outcome. Either self-reported physical activity was only recalled and categorized into fitness groups or exercise intolerance was just abstracted from medical records and not by means of a cardiopulmonary exercise testing. But neither dichotomization of the continuous variable daily activity into meeting the daily activity recommendation or not (data not shown) could not improve the model, nor a dichotomization of exercise capacity.

Thus, we could only speculate for the reasons in patients with CHD. We suppose that activity, exercise capacity, BMI and blood pressure are more dynamic values in patients with CHD in comparison to the healthy population. Our patients have to face multiple decisions regarding their health throughout life. That presupposes regular outpatient visits and for example decisions regarding changes in medical treatment, exercise prescription or even restriction from exercise because due to the appearance of cardiac issues, for example arrhythmia. Also scheduling for surgery followed by cardiac rehabilitation is an issue that suggest that we face more dynamic change in those examined cardiovascular risk factors during life. Epidemiologic research outline the opposite, namely constant and robust parameters for endpoint prediction, especially for peak oxygen uptake which seem to outperform physical activity for its predictive value.[19,20]

Conclusion

This study outlined that a single daily activity or exercise capacity measurement has no predictive value for short- or mid-term BMI or blood pressure changes in patients with CHD. With the background that the cardiovascular risk in patient with CHD seems to be less favorable than in healthy peers,[3-5] regular medical aftercare should not focus on congenital cardiac issues alone, but rather take regular cardiovascular risk factor assessment and counseling into account. A single assessment of physical activity or cardiopulmonary fitness is not enough.

Limitations

The study subgroup is relatively small and our patients seem to present an active cohort with a rather normal BMI and normal physical activity, which limits our statistical power. Regression to the mean seems to limit the statistical power at least in the prediction of blood pressure change.

Furthermore the short follow-up in this study limited the outcome to soft variables, that their self are only risk factor, and not the hard endpoint of survival, myocardial infarction or stroke.

Acknowledgment

There are no conflict of interest.

References

1. Khairy P, Ionescu-Ittu R, Mackie AS, Abrahamowicz M, Pilote L, Marelli AJ (2010) Changing mortality in

congenital heart disease. J Am Coll Cardiol 56: 1149-1157

2. Marelli AJ, Mackie AS, Ionescu-Ittu R, Rahme E, Pilote L (2007) Congenital heart disease in the general population: changing prevalence and age distribution. Circulation 115: 163-172

3. Moons P, Van Deyk K, Dedroog D, Troost E, Budts W (2006) Prevalence of cardiovascular risk factors in adults with congenital heart disease. Eur J Cardiovasc Prev Rehabil 13: 612-616

4. Tutarel O (2014) Acquired heart conditions in adults with congenital heart disease: a growing problem. Heart 100: 1317-1321

5. Rosenthal TM, Leung ST, Ahmad R, Young T, Lavie CJ, Moodie DS, Shah S (2016) Lifestyle Modification for the Prevention of Morbidity and Mortality in Adult Congenital Heart Disease. Congenit Heart Dis:

6. Khan KM, Thompson AM, Blair SN, Sallis JF, Powell KE, Bull FC, Bauman AE (2012) Sport and exercise as contributors to the health of nations. Lancet 380: 59-64

7. Dua JS, Cooper AR, Fox KR, Graham Stuart A (2010) Exercise training in adults with congenital heart disease: feasibility and benefits. Int J Cardiol 138: 196-205

8. Duppen N, Takken T, Hopman MT, Ten Harkel AD, Dulfer K, Utens EM, Helbing WA (2013) Systematic review of the effects of physical exercise training programmes in children and young adults with congenital heart disease. Int J Cardiol:

9. Takken T, Giardini A, Reybrouck T, Gewillig M, Hovels-Gurich HH, Longmuir PE, McCrindle BW, Paridon SM, Hager A (2012) Recommendations for physical activity, recreation sport, and exercise training in paediatric patients with congenital heart disease: a report from the Exercise, Basic & Translational Research Section of the European Association of Cardiovascular Prevention and Rehabilitation, the European Congenital Heart and Lung Exercise Group, and the Association for European Paediatric Cardiology. Eur J Prev Cardiol 19: 1034-1065

10. Diller GP, Giardini A, Dimopoulos K, Gargiulo G, Müller J, Derrick G, Giannakoulas G, Khambadkone S, Lammers AE, Picchio FM, Gatzoulis MA, Hager A (2010) Predictors of morbidity and mortality in contemporary Fontan patients: results from a multicenter study including cardiopulmonary exercise testing in 321 patients. Eur Heart J 31: 3073-3083

11. Giardini A, Hager A, Lammers AE, Derrick G, Müller J, Diller GP, Dimopoulos K, Odendaal D, Gargiulo G, Picchio FM, Gatzoulis MA (2009) Ventilatory efficiency and aerobic capacity predict event-free survival in adults with atrial repair for complete transposition of the great arteries. J Am Coll Cardiol 53: 1548-1555

12. Müller J, Hager A, Diller GP, Derrick G, Buys R, Dubowy KO, Takken T, Orwat S, Inuzuka R, Vanhees L, Gatzoulis M, Giardini A (2015) Peak oxygen uptake, ventilatory efficiency and QRS-duration predict event free survival in patients late after surgical repair of tetralogy of Fallot. Int J Cardiol 196: 158-164

13. Buys R, Van De Bruaene A, Muller J, Hager A, Khambadkone S, Giardini A, Cornelissen V, Budts W, Vanhees L (2013) Usefulness of cardiopulmonary exercise testing to predict the development of arterial hypertension in adult patients with repaired isolated coarctation of the aorta. Int J Cardiol 168: 2037-2041

14. Dulfer K, Helbing WA, Duppen N, Utens EM (2014) Associations between exercise capacity, physical activity, and psychosocial functioning in children with congenital heart disease: A systematic review. Eur J Prev Cardiol 21: 1200-1215

15. Müller J, Hess J, Hager A (2012) Daily physical activity in adults with congenital heart disease is positively correlated with exercise capacity but not with quality of life Clin Res Cardiol 101: 55-61

16. Müller J, Hess J, Hager A (2014) Sense of coherence, rather than exercise capacity, is the stronger predictor to obtain health-related quality of life in adults with congenital heart disease. Eur J Prev Cardiol 21: 949–955

17. Rowlands AV, Thomas PW, Eston RG, Topping R (2004) Validation of the RT3 triaxial accelerometer for the assessment of physical activity. Med Sci Sports Exerc 36: 518-524

18. Reas DL, Nygard JF, Svensson E, Sorensen T, Sandanger I (2007) Changes in body mass index by age, gender, and socio-economic status among a cohort of Norwegian men and women (1990-2001). BMC Public Health 7: 269

19. Myers J, Kaykha A, George S, Abella J, Zaheer N, Lear S, Yamazaki T, Froelicher V (2004) Fitness versus physical activity patterns in predicting mortality in men. Am J Med 117: 912-918

20. Myers J, Nead KT, Chang P, Abella J, Kokkinos P, Leeper NJ (2015) Improved reclassification of mortality risk by assessment of physical activity in patients referred for exercise testing. Am J Med 128: 396-402

21. Myers J, Prakash M, Froelicher V, Do D, Partington S, Atwood JE (2002) Exercise capacity and mortality among men referred for exercise testing. N Engl J Med 346: 793-801

22. Williams PT (2001) Physical fitness and activity as separate heart disease risk factors: a meta-analysis. Med Sci Sports Exerc 33: 754-761

23. Juonala M, Magnussen CG, Venn A, Dwyer T, Burns TL, Davis PH, Chen W, Srinivasan SR, Daniels SR, Kahonen M, Laitinen T, Taittonen L, Berenson GS, Viikari JS, Raitakari OT (2010) Influence of age on associations between childhood risk factors and carotid intima-media thickness in adulthood: the Cardiovascular Risk in Young Finns Study, the Childhood Determinants of Adult Health Study, the Bogalusa Heart Study, and the Muscatine Study for the International Childhood Cardiovascular Cohort (i3C) Consortium. Circulation 122: 2514-2520

24. Mahoney LT, Burns TL, Stanford W, Thompson BH, Witt JD, Rost CA, Lauer RM (1996) Coronary risk factors measured in childhood and young adult life are associated with coronary artery calcification in young adults: the Muscatine Study. J Am Coll Cardiol 27: 277-284

25. Berenson GS, Srinivasan SR, Bao W, Newman WP, 3rd, Tracy RE, Wattigney WA (1998) Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults. The Bogalusa Heart Study. N Engl J Med 338: 1650-1656

26. Srinivasan SR, Bao W, Wattigney WA, Berenson GS (1996) Adolescent overweight is associated with adult overweight and related multiple cardiovascular risk factors: the Bogalusa Heart Study. Metabolism 45: 235-240

27. Stefan MA, Hopman WM, Smythe JF (2005) Effect of activity restriction owing to heart disease on obesity. Arch Pediatr Adolesc Med 159: 477-481.

28. Tikkanen AU, Opotowsky AR, Bhatt AB, Landzberg MJ, Rhodes J (2013) Physical activity is associated with improved aerobic exercise capacity over time in adults with congenital heart disease. International Journal of Cardiology 168: 4685-4691