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Original article

Health-Related Fitness Profiles in Adolescents With Complex Congenital Heart Disease

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A B S T R A C T

Purpose: This study investigates whether subgroups of different health-related fitness (HrF) profiles exist among girls and boys with complex congenital heart disease (ConHD) and how these are associated with lifestyle behaviors.
Methods: We measured the cardiorespiratory fitness, muscle strength, and body composition of 158 adolescents aged 13–16 years with previous surgery for a complex ConHD. Data on lifestyle behaviors were collected concomitantly between October 2010 and April 2013. A cluster analysis was conducted to identify profiles with similar HrF. For comparisons between clusters, multivariate analyses of covariance were used to test the differences in lifestyle behaviors.
Results: Three distinct profiles were formed: (1) *Robust* (43, 27%; 20 girls and 23 boys); (2) *Moderately Robust* (85, 54%; 37 girls and 48 boys); and (3) *Less robust* (30, 19%; 9 girls and 21 boys). The participants in the Robust clusters reported leading a physically active lifestyle and participants in the Less robust cluster reported leading a sedentary lifestyle. Diagnoses were evenly distributed between clusters.
Conclusions: The cluster analysis attributed some of the variability in cardiorespiratory fitness among adolescents with complex ConHD to lifestyle behaviors and physical activity. Profiling of HrF offers a valuable new option in the management of person-centered health promotion.

IMPLICATIONS AND CONTRIBUTION

Profiling of health-related fitness and its relation to lifestyle behaviors offers a valuable new option in the management of person-centered health promotion among adolescents with complex congenital heart disease.

The life expectancy of adolescents with congenital heart disease (ConHD) has improved substantially over recent decades [1]. Sixty years ago, approximately 90% of patients died before they reached adulthood; more than 90% now survive [2]. Illnesses once considered fatal have become chronic and patients' care needs are changing [3].

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Physical activity is essential for adolescents with ConHD [4]. Despite existing recommendations of physical activity for patients with restrictions due to dysfunction of the heart and the great vessels [5], person-centered implementation strategies are still in the development phase [6].

Overweight due to inactivity adds to comorbidity in adolescents with ConHD [7], and one of the future challenges in clinical practice is to ensure meaningful promotion of physical activity [8]. Adolescents with ConHD whose activity is not restricted by their cardiac condition are generally recommended to adhere to public health physical activity recommendations [6]. Given that many healthy adolescents find it difficult to adhere to public health recommendations, there is reason to believe that this is also challenging for adolescents with ConHD.

Physical activity refers to leisure-time activity, occupational- and school-related activity, and exercise training and sports [9]. Physical activity is related in a complex way to health, morbidity, and mortality outcomes, and it has been suggested that physical activity interacts with health-related fitness (HrF) [10]. HrF includes cardiorespiratory fitness and is affected by environmental conditions, lifestyle behaviors, personal attributes, the physical and social environment, and heredity, as well as neurological and developmental abnormalities [9,11]. Thus, HrF is an important marker of individual health and well-being [12].

Cluster analysis allocates individuals into groups on the basis of selected shared characteristics; it has been used to examine associations between clusters of lifestyle behaviors in healthy adolescents and age, gender, and health outcomes [13]. The present study focuses on the reverse, namely, whether clustering of health outcomes is associated with lifestyle behaviors. To the best of our knowledge, no such associations have been reported among adolescents with ConHD. Consequently, the aim of this study was to use HrF profiles to identify clusters of adolescents with ConHD and examine if lifestyle behaviors differ between clusters.

Methods

Study population

A Danish nationwide sample was recruited by letter and consisted of 158 adolescents aged 13–16 years with complex ConHD, defined as follows: patients vulnerable to additional acquired comorbidities that impact their cardiac care and thus assigned to lifelong follow up at specialist centres [14]. All participants had no symptoms (New York Heart Association 1) [15] and were not subject to any restrictions on competitive sports [16].

Written informed consent was obtained from the adolescents and their parents.

Variables and measurement

HrF was assessed by the following components: cardiorespiratory fitness, muscle strength, and body composition. Cardiorespiratory fitness was measured using peak oxygen uptake (VO_2 peak = mL O_2/kg/min), heart rate (HR) reserve (maximal HR−HR at rest), oxygen pulse (O_2/HR = volume of oxygen consumed by the body per heartbeat), and Watt max (maximal workload sustained for 1 minute) during an incremental cardiopulmonary exercise test performed on a bicycle ergometer (Monark Ergomedic 839E, Monark Exercise AB, Vansbro, Sweden). After 10 minutes warm up, the patient undergoes the Godfrey cycle ergometer protocol to elicit a maximal oxygen uptake response. Muscle strength was measured as isometric hand grip strength in kilograms by a North Coast Hydraulic Dynamometer (PROcare, Roskilde, Denmark) and the highest of three values was recorded [17]. Body composition was measured by body mass index (BMI, kg/m^2) and the sum in millimeters of skinfolds at four sites (biceps, triceps, subscapular, and suprailiac) [18].

Lifestyle behaviors were measured by questions validated by HBSC, a collaborative cross-national research study, monitoring various health and lifestyle determinants in school-aged children [19]. These were supplemented by questions, developed for adolescents with ConHD [20]. All items had five response categories. The mean score (range, 1–5) was used as a continuous. Baseline data were collected between October 2010 and March 2013. All tests were conducted by the same investigators at a single test site. All questionnaires were filled out electronically; parents were absent. The Danish Data Protection Agency (2007-58-0015) and the Regional Ethics Committee approved the trial protocol (H-1-2010-025) before enrollment of the first participant. Informed and signed consent was obtained from both the adolescents and their parents.

Statistical analysis

All statistical tests were performed in SPSS statistical software for Windows (20.0; SPSS Inc., Chicago IL). HrF variables were grouped into strongly interrelated profiles by a combination of hierarchical and nonhierarchical cluster analysis [21]. First, a hierarchical cluster analysis estimated the number of likely clusters by measuring the similarity within several cluster solutions by an agglomerative solution, Ward's method [22]. The similarity measure of Euclidean distances, which uses the error sum of squares and fuses the two clusters whose fusion results in the minimum increase in the error sum of squares, was applied [23]. Each participant's characteristics were then joined to the group where he or she added least to within-group variability. Three clusters appeared to be solid on the basis of multiple iterations, a dendrogram, and an elbow test [22]. Second, a nonhierarchical *k*-cluster analysis was used to produce the three clusters by placing each participant in the cluster that resulted in the smallest increase in the overall sum of squared within-cluster distances.

To detect any differences between clusters in relation to lifestyle behaviors, multivariate analyses of covariance were undertaken across several lifestyle variables. To control for Type I error due to multiple testing, only a significance level of .05 after Bonferroni correction was accepted.

Results

Three stable clusters represented 158 participants comprising 66 (41%) girls. The mean age of girls was 14.6 years (standard deviation [SD], ±1.3); and the mean age of boys was 14.6 years (SD, ±1.2). Mean oxygen uptake in girls and boys was 37.5 (±8.1) and 47.9 (±7.9), respectively. All tests were completed in concordance with guidelines and no tests were ended because of criteria for ending tests [24].

Cluster names were on the basis of the characteristics of the HrF variables that formed them. Cluster 1, Robust, included 43 participants, 27% of the total sample; this group of very fit and physically strong adolescents included 20 (47%) girls. Cluster 2, Moderately robust, included 85 participants, 54% of the total sample;