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Original Article

Role of fitness as moderator of improvements in health-related quality of life

MIGUEL ANGEL PEREZ-SOUSA[1], PEDRO R. OLIVARES[2], ROCIO CARRASCO-ZAHINOS[3], NARCIS GUSI[4]
[1,2,3] Epidemiology of Physical Activity and Fitness Across the Lifespan (EPAFit) Research Group, Faculty of Education, University of Seville, Seville, SPAIN;
[1,2]Facultad de Educación, Psicología y Ciencias del Deporte, Universidad de Huelva, SPAIN;
[3]Laboratorio de Ciencias de la Actividad Física, el Deporte y la Salud, Universidad de Santiago de Chile, USACH, Santiago 9160030, CHILE.
[4] Faculty of Sport Sciences, University of Extremadura, 10071, Cáceres, SPAIN.

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Abstract
Background: This study aimed to determine the effects on the quality of life (QoL) of an exercise program in obese children and detect what physical fitness components are responsible for the enhancement of the QoL **Method:** One hundred twenty-one obese and overweight children were part of an exercise group (9.4 ± 2.1 years old) that participated in a 6-months exercise program that combined sports practice and social tasks. Forty-nine obese and overweight children were part of the control group (8.9 ± 1.8 years old). Anthropometrics characteristics, physical fitness [handgrip, core strength, standing long jump (SLJ), agility, range of motion (ROM), and cardiorespiratory fitness (CRF)], and QoL were measured. Analysis of covariance was performed to analyse the improvement. Moderation analysis with bootstrapping was also used to examine what improvements in physical fitness moderators of the QoL change. Additionally, was executed the Johnson-Neyman procedure to determine the threshold from which the improvement of physical fitness moderates the effects on QoL. **Results**: A significant improvement was found in VAS after the 6-months exercise program. The physical fitness moderators of the QoL changes were Core (B = 0.34, CI = 0.05 to 0.63, ES = 0.01), SLJ (B = 0.83, CI = -0.02 to 0.03, ES = 0.8), and agility (B = 3.78, CI = 1.06 to 6.50, ES = 0.0). **Conclusion:** Physical exercise programs aimed at young people who are overweight and obese should focus on the development of muscle strength and agility to enhance their QoL
Keywords: obesity, overweight, quality of life, physical fitness.

Background

Childhood obesity is a significant public health problem worldwide, causing a higher risk of developing diseases and psychological problems that can continue to cause effects into adulthood (Gordon-Larsen et al., 2004). The adverse health effects of obese and overweight children are due to increasing physical comorbidities, such as a high risk of hypertension, hyperinsulinemia, dyslipidemia, and type 2 diabetes (2). There are also psychological disorders such as anxiety and depression (Rankin et al., 2016), relational problems (Janssen et al., 2004), or poor self-esteem (Rankin et al., 2016). Both physical and psychological features are closely related to the health-related quality of life (HRQoL), which is defined as a multidimensional concept that includes physical, mental, social, and emotional well-being self-report (U Ravens-Sieberer et al., 2001). Several studies have shown that overweight and obese youth have lower HRQoL than average-weight peers (Bermejo-Cantarero et al., 2017; Kesztyüs et al., 2013; Tsiros et al., 2009). Also, these children are characterised by performing low physical activity (PA) (Hills et al., 2011) and consequently have a lower physical fitness level (Morales et al., 2013; F B Ortega et al., 2008). Many studies in the current literature analyse the improvements of the HRQoL based on physical exercise in children and adolescents who are overweight or obese (Finne et al., 2013; Morano et al., 2016; Zahner et al., 2006). In this sense, there is enough evidence of the beneficial effects of interventions based on physical exercise on HRQoL in obese children. However, as of today, the research needs to answer questions such as when, under what circumstances, or in what types of people do or do not affect treatment (Hayes, 2013). which variables can improve or worsen the effects of the treatment, and even set the threshold necessary to reach for the specified effects to occur (Hayes, 2013). In this way, several studies have applied moderation analysis in children. Gerber analysed the moderator effect of cardiorespiratory fitness between severity of life events and HRQoL (Gerber et al., 2017). Mitchell studied the interaction of cardiorespiratory fitness between obesity and physical self-perception (Mitchell et al., 2012). Guardabassi examined the role of stigma experiences in the relationship between body weight and HRQoL (Guardabassi et al., 2017), and Hayward studied the interaction effect of weight perception into weight status-HRQoL relationship (Hayward et al., 2014). However, to our knowledge, it has not been considered that improvements in physical fitness components can moderate the

Corresponding author: MIGUEL ANGEL PEREZ-SOUSA: perezsousa@gmail.com

improvement of the HRQoL in overweight or obese children. Accordingly, the aim of this study was three-fold: (i)to observe the effect of a 6-months exercise program on HRQoL in overweight or obese children; (ii) to detect what physical fitness components are moderators of the improvement in the HRQoL; and (iii) to know what is the estimated point of the increase from which a physical fitness component moderates the enhance in the HRQoL.

Methods

Participants and study design The study is a secondary analysis of a public physical exercise program for overweight and obese children, whose main results were published recently (Perez-Sousa et al., 2019). Differing from the previous analysis, the present study analysed HRQoL based on an Euroqool questionnaire and performed moderation analysis. The sample of study subjects included 168 overweight and obese children aged 9.3 ± 2.1 years, who were assessed in the framework of a real service funded by the Extremadura government with public funds and was carried out by the University of Extremadura, Spain. The intervention group were referred to an exercise program detailed below. The control group was only enrolled for assessment before and at the end of the intervention but continued with their normal life. The intervention program was carried out in three different cities in the region of Extremadura. The exercise program and the evaluations were directed by a graduate in Sports Science with experience in the use of the test battery and questionnaires explained below.

An advertising campaign recruited the participants at primary care centres, schools, sports clubs, and neighbourhood communities that promoted participation in the study through an information stand where posters and flyers were disseminated to parents, teachers, social workers, nurses, and physicians. The campaign included the following: a) support of the study by the regional government and the university, b) participants did not pay any fees, c) participants received an individual health-related fitness report after taking part in the test battery and completing the HRQoL questionnaire, d) participants would undergo a short medical examination to ensure that they could do physical activity. The participants had to comply with the following inclusion criteria: be overweight or obese, have the ability to move themselves, not suffer from any disease that made it impossible to do PA, sign the informed consent themselves or have their parents do so, and understand each item from the questionnaire and perform the test battery safely. This study was approved by the Committee on Biomedical Ethics of the University of Extremadura (Ref. 98/2007) and followed the precepts of the Declaration of Helsinki.

Exercise Program The program consisted of 60 min of supervised physical activity divided into two sessions per week for 6-months. The plan was more focused on empowering children to get resources to play with others than in sports or physical fitness performance for the short term. The activities consisted of physical activities in fun group dynamics to teach basic technical sport skills (soccer, basketball, athletics –running and jumping-, walking with stilts, hockey without skates) and social skills (group creation or managing to play in playground or leisure time) to prepare kids to join physical activities with other children and avoid the possible bullying due to their low previous conditioning or performance.

Measurements Health-related quality of life The Spanish version of the EQ-5D-Y survey (22) includes a descriptive section made up of five domains with three answer levels ("no problems," "some problems," and "a lot of problems"). The questionnaire domains are “mobility”, “self-care”, “usual activities”, “pain and discomfort”, and “worried sad or unhappy”. It also includes a visual analogue scale (VAS) for the subject to assess his/her health status in a range from 0 to 100, where 0 means the worst health status and 100, the best health status. Anthropometric data Body weight was measured to the nearest 0.1 kg using a Tanita SC-330, (Tanita Corp., Japan). Height was estimated with an aluminium stadiometer (Seca 713 model, Postfach, Germany) to the nearest 1 mm. BMI was calculated as body weight divided by the squared height (kg/m2). The BMI variable was categorised into healthy weight, overweight, and obese according to the indications of Cole et al. (Cole et al., 2000).

Fitness Cardiorespiratory fitness (CRF): A 20 m shuttle run test was performed to assess aerobic endurance. Each participant completed only one trial of this test that consisted of running back and forth between two markers spaced 20 m apart at a specified minimum pace. Successive audible beeps indicated the pace. The initial speed was 8.5 km/h, and it increased by 0.5 km/h every minute. Therefore, the number of shuttles run by each subject corresponded to the maximum velocity achieved. The test ended when the subjects failed to reach the finish line by beep signal on two consecutive occasions. The total distance covered was recorded as the final result of the test (24). Handgrip strength (HGS) was measured using a handgrip dynamometer (TKK 5401 model, Tokyo, Japan) following a standardised protocol (Francisco B. Ortega et al., 2015). Two measurements were taken for each hand, and finally, the sum of the best for each hand was recorded. Central body strength (CORE) was assessed using the curl-up test (Pate et al., 2012). This test consisted of performing the maximal number of repetitions of sit-ups (up and back) in 30 seconds. Only one trial for this test was done. Squat Long Jump (SLJ) was used to assess lower body strength. The test consisted of jumping as far as possible, placing the subjects behind the jump line. The distance was measured in meters (m) from the starting line to the foot's heel nearest the starting line (Francisco B. Ortega et al., 2015). Range of Movement (ROM): The Sit and Reach test was executed to assess the ROM in pelvic and lumbar flexion and record the best of two trials (Muyor et al., 2014). Agility was assessed using the 4 x 10 m shuttle run test. The subjects ran as fast as possible between two ropes that were 10 m apart on the floor. The subjects had to cross each rope with both feet. The stopwatch was stopped when the subject crossed the line for the fourth time. Two trials were performed, and the best result was recorded (Francisco B. Ortega et al., 2015).

Statistical analysis A descriptive analysis using mean ± standard deviation for the continuous variables and frequency distribution for categorical variables was used to obtain the characteristics of the sample. Chi-squared for EQ-5D-Y dimensions and ANCOVA for VAS adjusted as covariates by age, sex, and baseline with 5,000 bootstrapping were applied to test baseline and post-exercise intervention changes. Moderation analysis was conducted using PROCESS macro with a bootstrap threshold of 10,000 and 95% confidence interval (CI) (Hayes, 2013) in IBM SPSS version 24. PROCESS uses ordinary least squares regression analysis to predict continuous variables (physical fitness outcome and VAS in the current study). The intervention condition constituted a dummy variable. The Johnson-Neyman technique was used to identify the point(s) in which the fitness component value moderates the improvement in the VAS. The Johnson-Neyman technique determines the region of significance on the relationship between independent and dependent variables (Hayes & Rockwood, 2016).

Results

One hundred twenty-one obese and overweight children were enrolled in the exercise group (9.4 ± 2.1 years old) and forty-nine obese and overweight children in the control group (8.9 ± 1.8 years old). The participant's characteristics are shown in Table 1.

Table 1. Participants characteristics by sex and group

	Control (n = 49)			Exercise (n = 121)			
	Overweight 11 (22.5) / Obese 38 (77.5)			Overweight 33 (27.3) / Obese 88 (72.7)			*p**
	Boys 24 (46.9)	Girls 25 (53.1)	Both sexs 49 (28.8)	Boys 64 (52.9)	Girls 57 (47.1)	Both sexs 121 (71.2)	
Weight (kg)	56.5 (16.8)	46.1 (10.3)	51.2 (14.7)	53.5 (14.6)	51.5 (14.9)	52.6 (14.7)	.567
Height (cm)	145.1 (10.9)	136.8 (8.1)	140.8 (10.3)	142.8 (12.3)	140.4 (13.5)	141.7 (12.9)	.583
BMI (kg/cm^2)	26.4 (3.9)	24.3 (3.4)	25.3 (3.7)	25.6 (3.9)	25.5 (3.5)	25.6 (3.7)	.665
Physical activity (min/week)	129.5 (61.1)	59.1 (34.0)	94.3 (17.1)	93.3 (59.3)	75.7 (34.9)	85.1 (16.4)	.559

Note: data expressed on mean and SD and frequencies and percentage; * Statistical differences based on student t-test except for height which was performed through the Mann-Whitney test

No significant differences were found on anthropometric characteristics and physical activity between control and exercise groups. However, girls from the exercise group performed more physical activity during one week than girls in the control group. Also, the boys in the control group accumulated more physical activity than boys in the exercise group. The changes in HRQoL from baseline to 6-months post-intervention are shown in Table 2.

Table 2. Mean ± SD, frequency (%) and significant differences between baseline and 6-months post intervention in HRQoL PROs in exercise group and control group.

Dimensions	**Control Group (n 49)**			**Exercise Group (n 121)**		
	baseline	post	*p**	baseline	post	*p**
EQ-5D-Y Mobility			.63			.13
no problems	48 (98.0)	40 (81.6)		110 (90.9)	118 (97.5)	
some probelms	1 (2.0)	9 (18.4)		11 (9.1)	3 (2.5)	
lots of problems	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
EQ-5D-Y LAM*			.01			.33
no problems	47 (95.9)	37 (75.5)		112 (92.6)	116 (95.9)	
some probelms	2 (4.1)	12 (24.5)		8 (6.6)	5 (4.1)	
lots of problems	0 (0.0)	0 (0.0)		1 (0.8)	0 (0.0)	
EQ-5D-Y UA*			.00			.01
no problems	44 (89.8)	38 (77.6)		108 (89.3)	117 (96.7)	
some probelms	5 (10.2)	11 (22.4)		13 (10.7)	4 (3.3)	
lots of problems	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
EQ-5D-Y P/D*			.02			.00
no problems	34 (69.4)	39 (79.6)		98 (81.0)	117 (96.7)	
some probelms	15 (30.6)	10 (20.4)		23 (19.0)	4 (3.3)	
lots of problems	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
EQ-5D-Y WSU*			.94			.85
no problems	45 (91.8)	36 (73.5)		105 (86.8)	119 (98.3)	
some probelms	4 (8.2)	13 (26.5)		15 (12.4)	2 (1.7)	
lots of problems	0 (0.0)	0 (0.0)		1 (0.8)	0 (0.0)	
EQ-5D-Y VAS	82.5 ± 16.8	77.1 ± 17.4		82.5 ± 16.0	90.2 ± 12.4	.00

*note: significant differences (p = <.05) baseline-post 6-months intervention computed as chi-squared for dimensions and ANCOVA adjusted by baseline and age and gender for VAS.
*SC (Selfcare), *UA (Usual Activities), *P/D (Pain/Discomfort), *WSU (Worried, Sad or Unhappy)

There are significant changes for the usual activities and pain/discomfort for both groups, but significant changes occurred for "selfcare" in the control group. However, "mobility" and "worried, sad or unhappy" dimensions did not improve after the exercise program for both groups. For health self-perception (VAS), there were significant changes ($p < .05$) adjusted by baseline age and sex. The results from moderation analysis can be observed in the supplementary table and revealed a significant effect ($p < .05$) of the exercise program on health self-perception, while not finding significant moderation effects on ΔCRF ($B = 0.00$, CI = -0.02 to 0.03, ES = 0.00), ΔHandgrip strength ($B = 0.77$, CI = -0.09 to 1.64, ES = 0.02), and ΔROM ($B = -0.01$, CI = -0.78 to 0.76, ES = 0.00). On the other hand, there exists moderation effect with positive change in ΔCore strength ($B = 0.34$, CI = 0.05 to 0.63, ES = 0.01), ΔSLJ ($B = 0.83$, CI = -0.02 to 0.03, ES = 0.8), and ΔAgility ($B = 3.78$, CI = 1.06 to 6.50, ES = 0.0). In the end, the Johnson-Neyman technique revealed an estimated low point of Δcore strength, ΔSLJ, and Δagility from which the enhancements of these physical fitness components moderate the change on health self-perception. Results can be observed in Figure 1, which shows the region of significance and the estimated point.

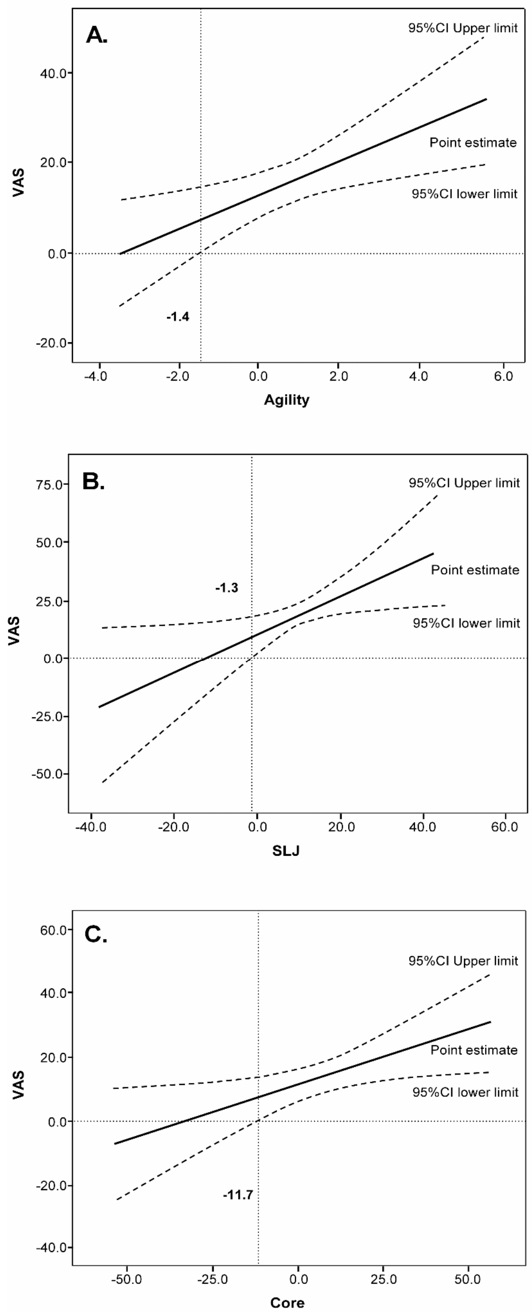

Figure 1. Johnson-Neyman plot for moderators SLJ (squat long jump), Core strength (CORE) andagility on the improvement on Quality of Life (VAS).

Discussion

This study determined what increases in physical fitness components moderated the improvements of the QoL in overweight and obese children that participated in the exercise program. Our study revealed that the enhancements of Core strength, SLJ, and agility moderated the intervention effect on their QoL. Therefore, the strength of this direct relationship (to participate vs not participate in the exercise program and the improvements on VAS) increases as the physical fitness level improves. This improvement in physical fitness could mean that actions closely related to motor performance in games and sports, such as jumping, moving quickly, and changing direction (Harold W. Kohl et al., 2013), are responsible for the improvement in the childrens' health self-perception. Our findings suggest that children who participated in the physical exercise program experienced improvements in their level of physical fitness and, therefore, had a better mastery of sports. In this way, children with better physical fitness levels have more self-esteem (Rodriguez-Ayllon et al., 2018), and this can be reflected in better health and esteem self-perceptions. Several studies have documented it (Liu et al., 2015).

In our study, the improvement in health self-perception was occasioned by participation in the physical exercise program since the Johnson-Neyman point of significance was slightly below the improvement of physical fitness. The results suggested that in this physical exercise program for overweight and obese children, a significant improvement of the QoL was observed even when there were no significant enhancements in the physical fitness components. However, this does not mean that there was no significant effect of the program on HRQoL of children, nor that the improvements in the fitness components did not imply an increase in health self-perception. Therefore, establishing that the predictor variable is significantly related to the outcome variable for one value of the moderator variable but not for another does not determine that the predictor variable's effect depends on the moderator variable (Hayes, 2018). In addition, the exercise program was not focused on the increase of physical fitness only. The program's aim was to improve social skills and empower children in sports activities.

Despite that the bibliography about moderation analysis and the Johnson-Neyman procedure on physical exercise programs is scarce, we have found several studies discussing our findings. Gerber M. et al. (Gerber et al., 2017) found an interaction effect of the CRF between the severity of life events and HRQoL in children. In another study, Nicholls L. et al (Nicholls et al., 2014) observed how parental encouragement moderates the inverse relationship between overweight status and physical well-being in children. Also, Mitchell NG et al. (Mitchell et al., 2012) found how the CRF moderates physical self-perception in obese children. Therefore, our results are in line with these studies since physical fitness moderated the health self-perception of the exercise program participants.

Regarding the beneficial effect of the exercise program on QoL, the results were similar to previous studies (Hilliard et al., 2013; Kuhl et al., 2012). In addition, it can be observed that the effect on EQ-5D-Y dimensions was beneficial for the exercise group since there was a significant effect of the exercise program in usual activities and pain/discomfort. While in the control group, “selfcare”, “usual activities”, and “worried sad or unhappy” dimensions, had significant differences from baseline to post-intervention but with a greater number of “some problems”. Therefore, the HRQoL in these dimensions got lower values by not participating in the exercise program. The non-significant effect on “mobility”, “selfcare”, and “worried, sad or unhappy” in the exercise group, may be due to a ceiling effect, and therefore the survey presents a lack of responsiveness. The high ceiling effect in the dimensions was also observed in previous studies on healthy children (U Ravens-Sieberer et al., 2010) and children with varying levels of chronic health conditions (Willems et al., 2009) and orthopaedic conditions (Vitale et al., 2001).

Our study has several limitations, especially the non-randomized groups, although this is solved with bootstrapping. Also, the low point in the Johnson-Neyman slope may be due to an insufficient intensity of the exercise program despite achieving significant results of health self-perception. Another limitation is the ceiling effect of the EQ-5D-Y. As a result, the changes should be interpreted with caution due to the EQ-5D-Y survey having three levels of response and the high ceiling effect suggested by several studies (U Ravens-Sieberer et al., 2010; Vitale et al., 2001; Willems et al., 2009).

One of the strengths of our study is that we applied a little-used statistics procedure in the field of physical activity and sport sciences, which allowed us to determine the reasons why determinate effects occured, what kind of subjects are responders and not responders, or under what conditions certain effects occur. In addition, this statistic procedure determined the region of significance and the threshold at which a third variable becomes significant. This will choose the dose-response necessary to provide a beneficial effect on the health-related outcome. Therefore, our study provides information on which physical fitness components have more weight than others to improve QoL among overweight/obese children.

The results have applications in aspects of sports medicine since we have begun to understand what improvements in fitness are necessary for significant changes in the QoL. In our research, the point of significance appears lower than the point of fitness improvement. However, it does not mean that the improvement of fitness is exclusively responsible for the change in the QoL. On the contrary, participation in the program where the primary activities were sports games with high social cohesion could be the key factor for the enhancement the QoL. Therefore, this may mean that for a significant improvement in the QoL to occur, it is more important to focus the program on social aspects than on improving fitness.

Conclusions

The current study observed the role of physical fitness components in overweight and obese children participants in a public exercise program and the effect on QoL. Agility, Core Strength, and SLJ were moderators of improving health self-perception with an estimated point below the enhancement of physical fitness. However, this did not establish that the exercise program's effect depends exclusively on the improvement of physical fitness. Therefore, children who did not improve their fitness enhanced their QoL. Consequently, participating in an exercise program that combined sports practice focused on developing muscle strength and agility, framed in social cohesion tasks, improved health self-perception in overweight and obese children.

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