Coll. Antropol. **48** (2024) 3: 177–185
Original scientific article
doi:10.5671/ca.48.3.6

BMI or Physical Fitness: What Matters Most for Children's Health? A Case of Apulia

Domenico Monacis[1], Angel-Alex Haisan[2], Dario Colella[3]

[1]Pegaso University, Department of Education and Sports Sciences, Naples, Italy
[2]"1 Decembrie 1918" University of Alba Iulia, Department of Physical Education and Sports, Alba Iulia, Romania
[3]University of Salento, Department of Biological and Environmental Sciences and Technologies, Lecce, Italy

ABSTRACT

The present study aims to evaluate the validity of a model based on BMI and the components of physical fitness to classify children into groupsof low-medium-high levels of physical efficiency and health, in a sample of 500 children aged 8–13 years (female = 262, male = 238). After collecting anthropometric data, the assessment of physical fitness has been carried out with SLJ, 10x4 and 6MWT. Children were then assigned to low, medium, and high physical fitness categories a priori based on their BMI-for-age Z-scores. The discriminatory analysis showed that only 71.3% of cases were correctly classified into physical fitness categories: the most discriminating variable to assign children to one group rather than another is not the BMI (p=0,225) but the 6MWT (p<0,01), as an indicator of cardiorespiratory fitness. This study provides new insights about the fundamental role in developing physical fitness during childhood.

Key words: *anthropometrics, percentile Z-scores, physical fitness, BMI, children.*

Introduction

International literature has widely documented the effectiveness of physical activity in improving health status from infancy to adulthood[1,2]. Despite World Health Organization's recommendations (WHO) for children and adolescents to practice at least sixty minutes of moderate-to-vigorous physical activity (MVPA) daily, combined with strength exercise 2–3 times x week[3], a large percentage of boys and girls (11–17) fail to comply these indications. Low adherence to physical activity and the ongoing diffusion of sedentary lifestyles worldwide[4,5] recognized sedentary habits as one of the most important health problems of the 21[st] century[6,7].

This negative worldwide trend, besides the increase of inactive and sedentary children and adolescents, is among the main determinant of childhood obesity with all related negative repercussions on the development of health status and physical fitness[8]. According to the Centers for Disease Control and Prevention (CDC), obesity in children could lead to several adverse effects in adulthood, including non-communicable diseases (i.e., hypertension, hypercholesterolemia, type-2-diabetes, asthma, sleep apnea, heart disease and different kind of cancer), but also anxiety, depression, low self-esteem and overall reduced quality of life[9]. Overweight and obesity are among chronic disease, and they are defined by multifactorial excessive bodyfat deposits that can negatively impact health status[5].

In this field, Physical Fitness (PF) is considered one of the most important health indicators and determinants for health status in children, and among the most significant predictors of morbidity and mortality in adults[10,11.] Since 1988 Lamb et al. affirmed the concept of physical fitness as health-indicator, due to the integration and interactions of significant physiological functions including musculoskeletal, cardiorespiratory and circulatory, metabolic and cognitive-neurological systems[12,13]. PF refers to the positive role of physical activity and healthy lifestyles, including nutritional habits, in improving personal wellbeing.

Caspersen distinguished between health-related components of physical fitness – such as cardiorespiratory endurance, muscular strength, muscular endurance, joint flexibility, and body composition – and skill-related fitness – such as, power, agility, reaction time, coordination, balance and speed, important for public health and athletic ability, respectively[14]. In this sense, the concept of physical

Received for publication April 20, 2024

fitness is strictly related to that of health-related fitness, understood as a multidimensional construct for developing and/or maintaining health as a consequence of physiological adaptation to increased overload[12, 15–16.]

In children and adolescents, most of physical fitness test batteries and protocols include the BMI assessment for determining children's implications for health and fitness[17,18]. The body mass index (BMI) is a measure of body mass relative to height, and represents one of the most practical, universally applicable, inexpensive solutions and a non-invasive anthropometric indicator for the classification of overweight and obesity[19].

However, the classification of overweight and obese children based on BMI only by sex and age is not free from errors (i.e., not taking into account lean and fat mass). Currently, the WHO classification for overweight and obesity uses growth charts standards based, among others, on weight/height/BMI-for-age scores[20]. Thus, the use of growth charts developed by the WHO for the definition of obesity in children and adolescents is recommended to favor a worldwide surveillance system[21].

In this field, scientific evidence highlighted lower muscular strength[22,23], aerobic endurance[24,25], speed and agility[26,27] in overweight-obese children compared to normal weight peers. Moreover, both lower levels of physical activity and increased BMI negatively affected children's physical fitness and health status[28–30].

Moreover, recent findings have highlighted the important role of muscle strength and cardiorespiratory endurance can moderate and moderate negative consequences of excess body weight and adiposity[31]. Research in this field highlighted that proper levels of muscular fitness and cardiorespiratory fitness can best provide good health status even in overweight/obese children and adolescents[32–34].

In other words, the "traditional" belief that a normal weight child corresponds to a healthy child could be wrong: adequate levels of muscle strength and aerobic endurance could make an overweight-obese child an "healthy child". In fact, errors could occur when classifying children an "unhealthy" because of high BMI-values. Starting from this statement, the present study aims to assess (a) differences in physical fitness according to gender and BMI Z-Scores in Italian children and (b) the validity of BMI as component to infer children's physical fitness levels.

Based on the literature review, the hypothesis tested are that normal-weight children will show better development of physical fitness components compared to overweight and obese groups, while the BMI should not explain completely the category of physical fitness.

Materials and Methods

Sample

This study employed 500 schoolchildren (female = 262, male = 238) aged 8–13 years old from Bari, who were recruited from schools joined the "Regional Observatory of Motor Development Project" promoted by the University of Salento (Lecce, Italy). In order to highlight psycho-pedagogical framework and best practices for physical education (PE) teachers' training in Southern Italy, the project was aimed at promoting healthy lifestyles and, physical fitness and correct eating habits in children and young adolescents. The Project was carried out from January to June 2019 in all six provinces of Apulia: Foggia, BAT, Bari, Brindisi, Lecce and Taranto.

Participants in this cross-sectional study were selected applying a multistage stratified sampling procedure according to BMI Z-scores and province (only children from Bari) to better ensure low variability between observations.

Anthropometric characteristics

The assessment of anthropometric characteristics included height, weight and body mass index (BMI) measurement. A digital portable stadiometer was used to measure height and weight (precision of about 0.1mm and 0.1 kg), without shoes. BMI was calculated used the following formula: weight (kg) / square of height (m^2). Moreover, date of birth (dd/mm/yyyy) and age (in years, months and days) were reported to calculate the BMI-for-age z-scores value[20]

AnthroPlus Software for personal computers[35] was used to carry out BMI-for-age indicators of children aged 8–13 years. According to BMI adjusted for age value and standard deviation (–3SD, –2SD, –1SD, +1SD, +2SD, +3SD), children were classified in different percentiles categories (3rd, 15th, 50th, 85th and 97th) from severe thinness to severe obesity[35].

Moreover, considering the widely documented relation between BMI and health-related physical fitness[32–34], children were a priori assigned to low, medium and high physical fitness category based on BMI-for-age Z-scores, as follows: 3° and 97° percentiles = low physical fitness, 15° and 85°percentiles = medium physical fitness, and 50° = high physical fitness.

Physical fitness assessment

The assessment of physical fitness was carried out with the following motor test: standing long jump (SLJ), 10x4 shuttle run (10x4) and 6 minutes walking test (6MWT) for assessing lower limbs strength, speed, agility and aerobic endurance, respectively. Assessment was conducted by physical education (PE) teachers and a team of Graduate in Motor and Sports Science involved in the Regional Observatory Project during curricular PE lessons from March to May 2019. After collecting anthropometric characteristics, children were asked to perform SLJ and 10x4 two times and only the best result has been considered in the analysis. Since 6MWT demonstrated to be physically demanding, it was performed once to avoid fatigue in schoolchildren.

Statistic

G*Power software [36] was used to determine adequate sample to conduct the analysis Setting medium effect size $f^2(V)=0{,}15$ [37] and α level at 0.05. Results suggested that 80 is an adequate sample size, that is consistent with 500 participants involved in the study. Quantitative variables were reported in terms of mean and standard deviations (SD), while qualitative and categorical data were described using frequencies (N).

After verifying normality of data, a 2 (gender) x 5 (BMI Z-scores categories) multifactorial analysis of variance (MANOVA) was used to explore potential main and interaction effects between gender and BMI Z-scores on physical fitness. Then, variance analysis (ANOVA) and independent-t test were applied to assess differences in physical fitness components scores according to BMI Z-scores and gender, respectively. According to Cohen, partial eta squared (0.01 = small effect, 0.06 = medium effect, and 0.14 or higher = large effect) and Cohen's *d* (0.2 = small effect, 0.5 = medium effect and 0.8 = large effect) were used to estimate effect size[37].

Discriminant factor analysis has been performed to develop and assess the robustness of the model for classifying children in low-, medium- and high-physical fitness categories, adopting BMI, SLJ, 10x4, and 6MWT as independent variables and BMI Z-scores categories as dependent variables by using the discriminant coefficients applying stepwise method. All statistical analysis were carried out with SPSS (vers. 26) and statistical indexes were set at p value <0.05.

Results

The sample's descriptive profile is described in Table 1 according to gender and BMI-for-age Z-scores. Since the number of variables observed in each group exceeds the number of dependent variables evaluated, it can be inferred that sample size is adequate for running analysis. In addition to mean and standard deviation, the number of children per BMI-for-age Z-scores has been reported for total sample, and for male and female, respectively, in terms of percentage.

A multivariate analysis of variance (MANOVA, Tables 2 and 3) was performed to assess the effect of gender and BMI-for-age Z-scores (independent variables) on physical fitness components (dependent variables). Significant values were reported according to gender (Pillai's trace: F (4.482) =2.827, p=0.024) and Z-scores (Pillai's trace: F (16.1940)=73,100, p<0.01) while the interaction effect was not significant.

Moreover, ANOVA has been conducted to assess the main effect of gender and Z-scores on variables considered. Since main effects for gender and Z-scores were significant, pairwise comparison via independent t-test (gender) and post-hoc analysis (Z-scores) was conducted.

Pairwise comparison in Table 2 highlighted that BMI was higher in male than female (p=0.02, d=0.09), and boys were faster than girls (p=0.02, d=0.08) with small effect size.

Post-hoc analysis revealed that BMI differs significantly between all groups (p<0.01), as well as 6MWT, where children in 50th percentile exhibited better performance compared to other groups (p<0.01). Significant differences were also reported in SLJ (15th vs 97th percentiles, p<0.01, and 50th vs 97th percentiles, p<0.01) and 10x4 (3 vs 97 percentiles, p<001, and 50th vs 97th, p<0.01). Medium to large partial eta squared values were found considering BMI and 6MWT differences.

A priori classification in low, medium and high physical fitness status was performed based on BMI-for-age Z-scores (3th and 97th percentiles = low physical fitness, 15th and 85thpercentiles = medium physical fitness, and 50th = high physical fitness). The discriminant analysis was performed for verifying the validity of the model based on the following discriminant variable: BMI, SLJ, 6MWT and10x4.

Since Box's m test was not significant, it can be assumed that the variance–covariance matrices in the categories of the dependent variable are same and subsequent analysis can be carried out.

Stepwise method revealed that two functions based on 6MWT and BMI can be developed due to their significant discriminating power, respectively.

The canonical correlations in Tables 4 and 5 provide indexes of overall model fit suggesting that 6MWT explains about 55.80% of the variation in grouping variable, while BMI explains only 0.30%.

The power of the variables is different in the two models: function 1 with 6MWT (absolute function value=0.794) and function 2 with BMI (absolute function value=0.985) as discriminant variables, respectively.

However, the value of Wilk's lambda – that is the estimate of variance of the dependent variable not explained by the independent variables – was tested by chi-square statistic and it was significant only for 6MWT (p<0.01) and not for BMI (p=0.225). Hence, it is possible to infer that only discriminant model for 6MWT is significant. Results showed that 6MWT was the only significant powerful predictor in discriminating categories of physical fitness.

The classification matrix in Table 6 summarizes the children correct and wrong classification in physical fitness groups based on the developed discriminant model. Results revealed that about 71.3% of children of the original grouped cases were correctly classified in the same categories.

Discussion

The objective of this study is to assess differences in physical efficiency in a sample of children and young adolescents according to gender and BMI-for-age Z-scores. The results showed significantly higher BMI values and

TABLE 1
PARTICIPANTS' DESCRIPTIVE PROFILE

BMI Z-Scores		Gender											
		Female						Male					
		N	Range	Min	Max	Mean	SD	N	Range	Min	Max	Mean	SD
< 3	Age	52	4.62	9.13	13.75	9.85	0.72	48	1.21	9.16	10.37	9.68	0.30
	Height	52	0.36	1.12	1.48	1.32	0.08	48	0.39	1.16	1.55	1.34	0.09
	BMI	52	2.40	12.20	14.60	13.18	0.49	48	1.40	12.20	13.60	12.99	0.34
	Walking	52	402	390	792	532.71	95.52	48	480	370	850	489.12	105.56
	SLJ	52	0.77	0.75	1.52	1.15	0.20	48	0.80	0.71	1.51	1.12	0.20
	10x4	52	11.30	8.22	19.52	14.82	1.99	48	15.40	3.70	19.10	13.97	3.08
< 15	Age	60	2.29	8.47	10.76	9.64	0.37	40	1.17	9.14	10.31	9.69	0.30
	Height	60	0.35	1.15	1.50	1.31	0.07	40	0.40	1.14	1.54	1.30	0.07
	BMI	60	3.60	11.10	14.70	14.24	0.54	40	1.20	13.70	14.90	14.37	0.32
	Walking	60	407	600	1007	690.73	95.79	40	302	600	902	687.40	76.32
	SLJ	60	1.04	0.76	1.80	1.15	0.20	40	0.77	0.85	1.62	1.19	0.21
	10x4	60	8.12	11.88	20.00	14.69	1.80	40	6.94	12.16	19.10	14.76	1.92
50	Age	51	1.32	8.99	10.31	9.57	0.33	49	1.69	8.45	10.14	9.71	0.32
	Height	51	0.29	1.18	1.47	1.32	0.05	49	0.24	1.19	1.43	1.31	0.05
	BMI	51	3.10	14.90	18.00	16.26	0.88	49	5.90	14.90	20.80	16.67	1.11
	Walking	51	339	741	1080	827.67	84.09	49	305	741	1046	834.10	77.29
	SLJ	51	0.82	0.75	1.57	1.18	0.18	49	0.84	0.76	1.60	1.17	0.21
	10x4	50	7.93	11.20	19.13	14.06	1.43	49	7.29	12.07	19.36	14.35	1.82
> 85	Age	55	1.20	8.99	10.19	9.58	0.30	45	1.21	9.01	10.23	9.54	0.28
	Height	55	0.35	1.14	1.49	1.32	0.07	45	0.33	1.09	1.42	1.32	0.06
	BMI	54	3.60	18.00	21.60	19.55	0.96	45	3.70	18.00	21.70	19.73	0.94
	Walking	55	377	643	1020	725.87	83.53	45	487	647	1134	740.67	101.99
	SLJ	55	0.94	0.74	1.68	1.08	0.22	45	1.25	0.40	1.65	1.15	0.22
	10x4	54	9.31	12.34	21.65	14.76	1.75	44	7.66	11.69	19.35	14.27	1.60
> 97	Age	44	1.90	8.35	10.26	9.58	0.39	56	2.05	9.07	11.12	9.76	0.34
	Height	44	0.31	1.17	1.48	1.33	0.07	56	0.26	1.21	1.47	1.35	0.05
	BMI	44	6.30	21.20	27.50	23.33	1.69	56	9.20	20.70	29.90	23.82	1.94
	Walking	44	397	590	987	669.27	87.47	56	417	588	1005	665.12	89.17
	SLJ	44	0.65	0.75	1.40	1.05	0.15	55	0.63	0.72	1.35	1.07	0.17
	10x4	44	14.22	12.58	26.80	15.73	2.68	55	6.92	11.88	18.80	14.72	1.42

N – number of participants. Min – minimum. Max – maximum. SD – standard deviation. Walking – 6-minute walking test, SLJ – standing long jump, 10x4 – shuttle run 10x4.

TABLE 2
GENDER DIFFERENCES

Dependent Variable	Groups	Mean	Std. Error	95% Confidence Interval		Mean Difference	Std. Error	Sig.	Cohen's *d*
				Lower Bound	Upper Bound				
BMI	Female	17.31	0.07	17.18	17.44	-.218	0.10	0.02	0.09
	Male	17.53	0.07	17.39	17.66				
Walking	Female	687.91	5.49	677.12	698.70	6.51	7.96	0.41	0.01
	Male	681.41	5.76	670.09	692.72				
SLJ	Female	1.12	0.01	1.10	1.15	-0.02	0.02	0.31	0.06
	Male	1.14	0.01	1.12	1.17		0.02	0.31	
10x4	Female	14.82	0.12	14.57	15.06	.406	0.18	0.02	0.08
	Male	14.41	0.13	14.16	14.67				

Sig – p value.

TABLE 3

DIFFERENCES ACCORDING TO WHO BMI'S PERCENTILES

Dependent Variable			Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference		Cohen's *d*
						Lower Bound	Upper Bound	
BMI	< 3	< 15	-1.22	0.15	0.000	-1.65	-0.79	-1.13
		50	-3.38	0.15	0.000	-3.81	-2.96	-0.85
		> 85	-6.55	0.15	0.000	-6.98	-6.12	-0.65
		> 97	-10.50	0.15	0.000	-10.93	-10.07	-0.82
	< 15	50	-2.16	0.15	0.000	-2.59	-1.73	-0.82
		> 85	-5.33	0.15	0.000	-5.76	-4.89	-0.99
		> 97	-9.27	0.15	0.000	-9.71	-8.84	-0.69
	50	> 85	-3.16	0.15	0.000	-3.59	-2.73	-0.96
		> 97	-7.11	0.15	0.000	-7.54	-6.69	-0.67
	> 85	> 97	-3.94	0.15	0.000	-4.38	-3.51	-0.70
Walking	< 3	< 15	-178.14	12.56	0.000	-213.59	-142.70	-0.96
		50	-319.62	12.47	0.000	-354.79	-284.45	-0.53
		> 85	-214.87	12.56	0.000	-250.30	-179.45	-0.44
		> 97	-156.05	12.51	0.000	-191.33	-120.77	-0.71
	< 15	50	-141.47	12.59	0.000	-176.99	-105.95	-0.56
		> 85	-36.73	12.68	0.040	-72.50	-0.95	-0.48
		> 97	22.04	12.63	0.810	-13.53	57.71	0.25
	50	> 85	104.74	12.59	0.000	69.24	140.24	1.09
		> 97	163.56	12.53	0.000	128.21	198.92	0.81
	> 85	> 97	58.82	12.62	0.000	23.21	94.43	0.72
SLJ	< 3	< 15	-0.03	0.02	1.000	-0.11	0.04	-0.15
		50	-0.04	0.02	1.000	-0.11	0.03	-0.21
		> 85	0.02	0.02	1.000	-0.05	0.10	0.13
		> 97	0.07	0.02	0.075	-0.00	0.15	0.38
	< 15	50	-0.01	0.02	1.000	-0.08	0.07	-0.06
		> 85	0.05	0.02	0.382	-0.02	0.13	0.27
		> 97	.11	0.02	0.001	0.02	0.18	0.53
	50	> 85	0.06	0.02	0.182	-0.01	0.14	0.34
		> 97	.11	0.02	0.000	0.03	0.19	0.59
	> 85	> 97	0.05	0.02	0.777	-0.02	0.12	0.25
10x4	< 3	< 15	-0.32	0.28	1.000	-1.13	0.47	-0.15
		50	0.19	0.28	1.000	-0.60	0.98	0.10
		> 85	-0.13	0.28	1.000	-0.93	0.67	-0.06
		> 97	-.82	0.28	0.037	-1.62	-0.02	-0.38
	< 15	50	0.51	0.28	0.700	-0.28	1.32	0.26
		> 85	0.19	0.28	1.000	-0.61	1.00	0.09
		> 97	-0.49	0.28	0.822	-1.30	0.30	-0.22
	50	> 85	-0.32	0.28	1.000	-1.12	0.48	-0.17
		> 97	-1.01	0.28	0.004	-1.81	-0.21	-0.48
	> 85	> 97	-0.69	0.28	0.155	-1.50	0.11	-0.31

Sig – p value.

TABLE 4

CANONICAL CORRELATIONS OF FUNCTION 1 AND 2

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	1.263	99.8	99.8	0.747
2	0.003	0.2	100.0	0.055
		Wilks' Lambda		
Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 2	0.441	402.774	4	0.000
2	0.997	1.474	1	0.225

Sig – p value.

TABLE 5

STRUCTURE MATRIX

	Function	
	1	2
Walking	.794	0.608
BMI	-0.172	.985

TABLE 6

CLASSIFICATION MATRIX

Physical Fitness Category			Predicted Group Membership			Total
			Low	Medium	High	
Original	Count	Low	161	29	10	200
		Medium	37	120	43	200
		High	0	24	76	100
	%	Low	80.5	14.5	5.0	100.0
		Medium	18.6	59.8	21.6	100.0
		High	0.0	24.0	76.0	100.0

shorter test times in 10x4 in boys than in girls. In addition, post-hoc analysis showed significant differences in BMI and 6MWT, with the group ranked at 50° percentile showing the best motor performance, while the group ranked at 3° percentile had the worst one.

These results are similar to other findings in literature, showing children with BMI value above or below the suggested ranges demonstrate lower physical fitness than those with normal BMI [38,39]. Moreover, the inverse relationship between body weight (or adiposity) and the development of physical fitness has been widely demonstrated[40], and normal body weight is a strong predictor of overall better physical fitness[41]. Muscular strength, speed and agility are significant predictors of health status in children and adolescents, as they are inversely related with body adiposity, body weight and cardiometabolic risk factors[42]. Furthermore, since significant differences were found with a medium-high effect size compared to BMI and 6MWT, the results highlight and reinforce the construction that normal weight children had better cardiorespiratory fitness than obese or underweight ones.

However, despite significant differences in BMI and 6MWT, the discriminating analysis showed that only 71.3% of cases were correctly classified in physical fitness categories. In fact, the most discriminating variable to assign children to one group rather than another is not the BMI (p=0,225) but the 6MWT (p<0,01), as an indicator of cardiorespiratory endurance. This finding sustains the concept suggested by Ortega et al. (2018) [31] according to which normal body weight could not be enough for maintaining good health status, advocating the importance of being physically active and physical fitness development[43,44].

In fact, children with high BMI and adequate development of cardiorespiratory endurance showed low cardiometabolic risk compared with those having low BMI but low aerobic endurance[41,43–49].Moreover, aerobic endurance is significant index of overall physical fitness status[50,51].Findings from this study are even more important if considering that higher aerobic endurance could enhance quality of life in children and adolescents, due to its important contribution for general health status[52]. Moreover, cardiorespiratory fitness is a significant mediator obesity development and daily physical activity[53] and contributes to significantly reduce excessive body weight in children and adolescent's[52]. Other studies have already shown that being overweight and/or obese is strictly related with lower levels of physical activity and cardiorespiratory endurance[53–56].

A recent study of González-Gálvez et al.[54] confirmed the "fat but fit paradox", highlighting the importance of cardiorespiratory fitness and muscular strength as predictors of lower cardiometabolic risk even in overweight and obese children. Results from this study can be useful for the development of public health guidelines and policies aimed at promoting physical activity and healthy lifestyles in primary schoolchildren. This could lead to a significant change in cultural models related to health and physical activity, shifting the interest from BMI and body weight to the assessment of physical fitness as an indicator of health.

The change of focus could, therefore, lead to a change in good practice and experimental interventions, especially in the school context, no longer oriented towards reducing overweight and obesity. In fact, school-based physical activity seems to have low effect in reducing body weight and BMI in schoolchildren[59,59], while they are effective in improving daily moderate to vigorous physical activity and overall physical fitness[60–62]. The prevention of obesity in childhood could, therefore, go from an adequate development of physical fitness, reversing the paradigm according to which "less fat is more fit".

The results of this study pointed out another important methodological consideration and reflection regarding the quanti-qualitative variables of physical activity to best promote physical fitness development. As suggested by Burden et al. (2022)[63], daily moderate-to-vigorous physical activity (MVPA) can best promote cardiorespiratory fitness in children and adolescents, so it is important for physical education teachers and educators enhance and translate findings from scientific literature into practice, developing multicomponent interventions aimed at promoting MVPA, structuring specific motor tasks to develop CRF, and modulating motor load parameters including high-intensity activity in physical education curriculum.

Finally, these findings suggest the fundamental role of school and physical education teachers as institution for improving and/or safeguarding health and well-being of the whole youngest community, fostering interventions in the physical and social environment, and the links with regional partners to translate scientific evidence into practice.

However, this study contains some weakness that limit the generalization of the results. At first, the variables included in the present analysis refers only BMI and physical fitness components without considering possible confounders and covariates linked to health status (i.e, levels of physical activity, dietary habits, psychological well-being, motor competence, perceived motor competence, enjoyment during PA, etc.) and socio-economic status that could contribute to better understanding of the topic. Moreover, despite the good correct classification rate (about 71%) of children in fitness categories, further studies are needed to carry out significant predictive power and generalize results. In fact, in this study only 6MWT – as indicator of cardiorespiratory fitness – adds significant contribution in model explanation: future studies should assess the role of other components of physical fitness (i.e., strength, speed, agility, flexibility, etc.) using different physical fitness tests to get a more comprehensive understanding of the children's health and fitness profiles.

Finally, the results of the present study should be interpreted without downplaying the clinical relevance of BMI, but only suggest or add new findings for public health promotion in children.

Conclusions

Promoting public health requires an assessment of health-related physical fitness components in early children and adolescents, which is unavoidable. The present study underscores the significance of cardiorespiratory fitness in distinguishing between low-to-high levels of physical fitness.

The present results can be useful for teachers and educators to carried out methodological and didactic implication in the field of physical activity, as it contributes to grown and increase a better understanding of developments of physical fitness during childhood.

Some key points can be pointed out: the need to expand the quantitative and qualitative opportunities for being physically active at school and in different context, and on the other hand the need to structure physical activity/education interventions aimed at increasing the intensity of aerobic physical activity. In fact, despite school-based interventions can be effective for promoting health and managing obesity, methodological implications should be adopted and turned to physical education teachers and educators to best increase time spent in physical activity and moderate to vigorous intensity. The proposal of multi-component activity program could have the potential to enhance children's adherence and participation in PA through multicomponent policies (physical education curriculum-education through sport, active-transport-daily motor activities-education to correct eating habits), which go beyond the "fight" against sedentary lifestyle and childhood obesity or the pursuit of sporting results. Since school represent one of the most important setting to promote healthy lifestyles, PE teachers' training for physical fitness development could provide significant health-oriented effects in children and adolescents.

Furthermore, future research could assess the mediating role of physical activity between anthropometric characteristics and physical fitness considering different/multiple methods, using sport participation and objective measures of physical activity as covariates, and evaluate the effectiveness of structured experimental interventions on the relation between physical fitness and BMI.

REFERENCES

1. MALM C, JAKOBSSON J, ISAKSSON A, Sports, 7 (2019) 127. doi: 10.3390/sports7050127. — 2. SINGH R, PATTISAPU A, EMERY MS, Trends Cardiovasc Med, 30 (2020) 407. doi: 10.1016/j.tcm.2019.10.002. — 3. BULL FC, AL-ANSARI SS, BIDDLE S, BORODULIN K, BUMAN MP, CARDON G, CARTY C, CHAPUT JP, CHASTIN S, CHOU R, DEMPSEY PC, DIPIETRO L, EKELUND U, FIRTH J, FRIEDENREICH CM, GARCIA L, GICHU M, JAGO R, KATZMARZYK PT, LAMBERT E, LEITZMANN M, MILTON K, ORTEGA FB, RANASINGHE C, STAMATAKIS E, TIEDEMANN A, TROIANO RP, VAN DER PLOEG HP, WARI V, WILLUMSEN JF, Br J Sports Med, 54 (2020) 1451. doi: 10.1136/BJSPORTS-2020-102955. — 4. GUTHOLD R, STEVENS GA, RILEY LM, BULL FC, The Lancet Child Adoles Health, 4 (2020) 23. doi:

10.1016/S2352-4642(19)30323-2. — 5. WORLD HEALTH ORGANIZATION, Obesity and overweight, World Health Organization. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight. — 6. BLAIR SN, Br J Sports Med, 43 (2009) 1. — 7. KATZMARZYK PT, The Lancet Global Health, 11 (2023), e2. doi: 10.1016/S2214-109X(22)00482-X. — 8. HILLS AP, ANDERSEN LB, BYRNE NM, Br J Sports Med, 45(2011), 866. doi: 10.1136/BJSPORTS-2011-090199. — 9. CENTERS FOR DISEASE CONTROL AND PREVENTION, Consequences of Obesity, Centers For Disease Control And Prevention. https://www.cdc.gov/obesity/adult-obesity-facts/index.html. — 10. ORTEGA FB, RUIZ JR, CASTILLO MJ, SJÖSTRÖM M, INT J OBES, 32 (2008) 1. doi: 10.1038/SJ.IJO.0803774. — 11. HILLMAN CH, ERICKSON KI, KRAMER AF, NAT REV NEUROSCI, 9 (2008) 58. doi: 10.1038/NRN2298. — 12. LAMB KL, BRODIE DA, ROBERTS K, Health Promot Int, 3 (1988) 171. doi: 10.1093/HEAPRO/3.2.171. — 13. FONSECA DEL POZO FJ, ALONSO JV, ÁLVAREZ MV, ORR S, CANTARERO FJL, Health Promot Perspect, 7 (2017) 197. doi: 10.15171/HPP.2017.35. — 14. CASPERSEN CJ, POWELL KE, CHRISTENSON GM, Public Health Rep, 100 (1985) 126. — 15. GOODWAY JD, OZMUN JC, GALLAHUE DL, Understanding Motor Development: Infants, Children, Adolescents, Adults (Jones & Bartlett Learning, Burlington, 2021). — 16. BRITTON Ú, ISSARTEL J, FAHEY G, CONYNGHAM G, BELTON S, Eur Phys Educ Rev, 26 (2019) 782. doi: 10.1177/1356336X19882060. — 17. ARTERO EG, ESPAÑA-ROMERO V, CASTRO-PIÑERO J, ORTEGA FB, SUNI J, CASTILLO-GARZON, MJ, RUIZ, JR, Int J Sports Med, 32 (2011) 159. doi: 10.1055/s-0030-1268488. — 18. CASTRO-PIÑERO J, ARTERO EG, ESPAÑA-ROMERO V, ORTEGA FB, SJÖSTRÖM M, SUNI J, RUIZ JR, Br J Sports Med, 44 (2010) 934. doi: 10.1136/bjsm.2009.058321. — 19. NUTTALL FG, Nutr Today, 50 (2015) 117. doi: 10.1097/NT.0000000000000092. — 20. WORLD HEALTH ORGANIZATION, WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development (WHO Press, Geneva, 2019). — 21. WANG Y, CHEN HJ, Use of Percentiles and Z-Scores in Anthropometry BT – Handbook of Anthropometry: Physical Measures of Human Form in Health and Disease (Springer New York, New York, 2012). doi: 10.1007/978-1-4419-1788-1_2 — 22. ALANIZ-ARCOS JL, ORTIZ-CORNEJO ME, LARIOS-TINOCO JO, KLÜNDER-KLÜNDER M, VIDAL-MITZI K, GUTIÉRREZ-CAMACHO C, BMC Pediatr, 23 (2023) 474. doi: 10.1186/S12887-023-04290-W — 23. MANZANO-CARRASCO S, GARCIA-UNANUE J, HAAPALA EA, FELIPE JL, GALLARDO L, LOPEZ-FERNANDEZ J, Eur J Pediatr, 182 (2023) 2345. doi: 10.1007/S00431-023-04887-4 — 24. BHAMMAR DM, ADAMS-HUET B, BABB TG, Med Sci Sports Exerc, 51 (2019) 2243. doi: 10.1249/MSS.0000000000002061. — 25. PETROVICS P, SANDOR B, PALFI A, SZEKERES Z, ATLASZ T, TOTH K, SZABADOS E, Int J Environ Res Public Health, 18 (2021) 1. doi: 10.3390/IJERPH18010134. — 26. BARROS WMA, SILVA KG DA, SILVA RKP, SOUZA AP DA S, SILVA ABJ DA, SILVA MRM, FERNANDES MSS, DE SOUZA SL, SOUZA VON, Front Endocrinol, 12 (2022) 1. doi: 10.3389/FENDO.2021.759165. — 27. CESCHIA A, GIACOMINI S, SANTAROSSA S, RUGO M, SALVADEGO D, DA PONTE A, DRIUSSI C, MIHALEJE M, POSER S, LAZZER S, Eur J Sport Sci, 17 (2016) 271. doi: 10.1080/17461391.2015.1030454. — 28. FIORI F, BRAVO G, PARPINEL M, MESSINA G, MALAVOLTA R, LAZZER S, PLoS One, 15 (2020) e0233362. doi: 10.1371/JOURNAL.PONE.0233362. — 29. MONACIS D, TRECROCI A, INVERNIZZI PL, COLELLA D, Int J Environ Res Public Health, 19 (2022) 1. doi: 10.3390/IJERPH191912567. — 30. VANDONI M, LOVECCHIO N, CARNEVALE PELLINO V, CODELLA R, FABIANO V, ROSSI V, ZUCCOTTI GV, CALCATERRA V, Children, 8 (2021) 1. doi: 10.3390/CHILDREN8090762. — 31. ORTEGA FB, CADENAS-SANCHEZ C, MIGUELES JH, LABAYEN I, RUIZ JR, SUI X, BLAIR SN, MARTÍNEZ-VIZCAINO V, LAVIE CJ, Prog Cardiovasc Dis, 61 (2018) 190. doi: 10.1016/J.PCAD.2018.07.008. — 32. GONZÁLEZ-GÁLVEZ N, LÓPEZ-MARTÍNEZ AB, LÓPEZ-VIVANCOS A, *Nutrients*, 16 (2024) 606. doi: 10.3390/nu16050606. — 33. QIN G, QIN Y, LIU B, Front Public Health, 10 (2022) 1047501. doi: 10.3389/fpubh.2022.1047501. — 34. MONACIS D, PASCALI G, COLELLA D, Pedagogy phys. cult. Sports, 28 (2024) 192. doi:10.15561/26649837.2024.0304. — 35. WORLD HEALTH ORGANIZATION, WHO AnthroPlus for personal computers Manual: Software for assessing growth of the world's children and adolescents (WHO Press, Geneva, 2019). — 36. FAUL F, ERDFELDER E, BUCHNER A, LANG AG, Behav Res Methods, 41 (2009) 1149. doi: 10.3758/BRM.41.4.1149. — 37. COHEN J, Statistical power analysis for the behavioral sciences (Academic Press, Cambridge, 2013). — 38. CHEN G, CHEN J, LIU J, HU Y, LIU Y, BMC Public Health, 22 (2022) 1680. doi: 10.1186/S12889-022-14089-6. — 39. CASONATTO J, FERNANDES RA, BATISTA MB, CYRINO ES, COELHO-E-SILVA MJ, DE ARRUDA M, VAZ RONQUE ER, J Child Health Care, 20 (2016), 294. doi: 10.1177/1367493515598645. — 40. GODOY-CUMILLAF A, FARÍAS-VALENZUELA C, DUCLOS-BASTÍAS D, GIAKONI-RAMÍREZ F, VÁSQUEZ-GÓMEZ J, BRUNEAU-CHÁVEZ J, BIZZOZERO-PERONI B, Medicine, 102 (2023), 1. doi: 10.1097/MD.0000000000033894. — 41. HO FK, SO HK, WONG RS, TUNG KTS, LOUIE LHT, TUNG J, MIRPURI S, CHOW B, WONG WHS, LEE A, IP P, Pediatr Obes, 15 (2020) e12646. — 42. GARCÍA-HERMOSO A, RAMÍREZ-CAMPILLO R, IZQUIERDO M, Sports Medicine, 49 (2019) 1079. doi: 10.1007/S40279-019-01098-6. — 43. POZUELO-CARRASCOSA DP, MARTÍNEZ-VIZCAÍNO V, TORRES-COSTOSO A, MARTINEZ MS, RODRÍGUEZ-GUTIÉRREZ E, GARRIDO-MIGUEL M, Child Obesity, 19 (2023) 282. doi: 10.1089/CHI.2022.0073. — 44. WEISSTAUB G, GONZALEZ BRAVO MA, GARCÍA-HERMOSO A, SALAZAR G, LÓPEZ-GIL JF, Transl Pediatr, 11 (2022) 1085. doi: 10.21037/TP-22-25. — 45. GONZÁLEZ-GÁLVEZ N, LÓPEZ-MARTÍNEZ AB, LÓPEZ-VIVANCOS A, Nutrients, 16 (2024) 1. doi: 10.3390/NU16050606. — 46. ERKELENZ N, KOBEL S, KETTNER S, DRENOWATZ C, STEINACKER JM, J Sports Sci Med, 13 (2014) 645. — 47. FOOTE SJ, VENEZIA A, WINKLER DJ, LOSCHE KR, WADSWORTH DD, Int J Exerc Sci, 12 (2019) 1302. — 48. SIGMUND E, SIGMUNDOVÁ D, Int J Environ Res Public Health, 17 (2020) 1. doi: 10.3390/IJERPH17238737. — 49. HONG I, COKER-BOLT P, ANDERSON KR, LEE D, VELOZO CA, Am J Occup Ther Off Publ Am Occup Ther Assoc, 70 (2016) 1. doi: 10.5014/AJOT.2016.021212. — 50. KASOVIĆ M, ŠTEFAN L, PETRIĆ V, BMC PulmMed, 21 (2021) 297. doi: 10.1186/S12890-021-01666-5. — 51. VAN WAELVELDE H, VANDEN WYNGAERT K, MARIËN T, BAEYENS D, CALDERS P, Infant Child Dev, 29 (2020) E2163. doi: 10.1002/ICD.2163. — 52. EVARISTO S, MOREIRA C, LOPES L, OLIVEIRA A, ABREU S, AGOSTINIS-SOBRINHO C, OLIVEIRA-SANTOS J, PÓVOAS S, SANTOS R, MOTA J, J Exerc Sci Fit, 17 (2019) 55. doi: 10.1016/J.JESF.2019.01.002. — 53. MUNTANER-MAS A, PALOU P, VIDAL-CONTI J, ESTEBAN-CORNEJO I, J Pediatr, 198 (2018) 90. doi: 10.1016/J.JPEDS.2018.02.068. — 54. GONZÁLEZ-GÁLVEZ N, RIBEIRO JC, MOTA, J. Cardiorespiratory Fitness, 19 (2022) 1. doi:/10.3390/IJERPH192316262. — 55. SYAM Y, ERIKA KA, FADILAH N, SYAHRUL S, ENFERMERÍA CLÍNICA, 31 (2021) S704. doi: 10.1016/J.ENFCLI.2021.07.021. — 56. KUMARI EKANAYAKE HD, SALIBI DG, TZENIOS N, Spec J Med Acad other Life Sci, 21 (2023) 1. doi: 10.58676/SJMAS.V1I6.40. — 57. GUERRA PH, NOBRE MRC, SILVEIRA JAC, TADDEI JAAC, Clinics, 68 (2013)1263. doi: 10.6061/CLINICS/2013(09)14. — 58. JACOB CM, HARDY-JOHNSON PL, INSKIP HM, MORRIS T, PARSONS CM, BARRETT M, HANSON M, WOODS-TOWNSEND K, BAIRD J, Int J Behav Nutr Phys Act, 18 (2021) 1. doi: 10.1186/S12966-020-01065-9. — 59. SOARES R, BRASIL I, MONTEIRO W, FARINATTI P, Bodyw Mov Ther, 33 (2023) 154. doi: 10.1016/J.JBMT.2022.09.004. — 60. NEIL-SZTRAMKO SE, CALDWELL H, DOBBINS M, Cochrane Database Syst Rev, 9 (2021) 1. doi: 10.1002/14651858.CD007651.PUB3. — 61. BRANDES B, BUSSE H, SELL L, CHRISTIANSON L, BRANDES M, Prev Med, 155 (2022) 1.doi: 10.1016/J.YPMED.2021.106920. — 62. ZHOU X, LI J, JIANG X, Sci Rep, 14 (2024) 14301. doi: 10.1038/S41598-024-64830-X. — 63. BURDEN SJ, WEEDON BD, TURNER A, WHAYMAND L, MEANEY A, DAWES H, JONES A, Pediatrics, 150 (2022) e2021056003. doi: 10.1542/PEDS.2021-056003.

D. Monacis

Pegaso University, Department of Education and Sports Sciences, Centro Direzionale Isola F2, 80143 Napoli NA, Italy
e-mail: Domenico.monacis@unipegaso.it

BMI ILI FIZIČKA SPREMNOST: ŠTO JE VAŽNIJE ZA ZDRAVLJE DJECE? SLUČAJ APULIJE

S A Ž E T A K

Ova studija ima za cilj procijeniti valjanost modela temeljenog na BMI-u i komponentama tjelesne spremnosti za klasificiranje djece u kategorije niske-srednje-visoke razine tjelesne učinkovitosti i zdravlja i to na uzorku od 500 djece u dobi od 8–13 godina (Ž = 262, M = 238). Nakon prikupljanja antropometrijskih podataka, procjena tjelesne spremnosti je provedena sa SLJ, 10x4 i 6MWT. Djeci su zatim dodijeljene niske, srednje i visoke kategorije tjelesne spremnosti a priori na temelju njihovih Z-rezultata BMI za dob. Diskriminantna analiza pokazala je da je samo 71,3% slučajeva ispravno klasificirano u kategorije tjelesne sposobnosti: najdiskriminirajuća varijabla za svrstavanje djece u jednu skupinu, a ne u drugu, nije BMI (p=0,225), već 6MWT (p<0,01), kao pokazatelj kardiorespiratorne sposobnosti. Ova studija pruža nove uvide o temeljnoj ulozi u razvoju tjelesne spremnosti tijekom djetinjstva.