Received: 18 January 2023 | Revised: 21 February 2023 | Accepted: 23 February 2023

DOI: 10.1111/sms.14345

ORIGINAL ARTICLE

WILEY

Is higher physical fitness associated with better psychological health in young pediatric cancer survivors? A cross-sectional study from the iBoneFIT project

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Funding information
Spanish Ministry of Science and Innovation, Grant/Award Number: FPU20/05530 and PID2020-117302RA-I00; La Caixa Foundation, Grant/Award Number: LCF/BQ/PR19/11700007; University of Granada Plan Propio de Investigación 2021—Excellence actions: Unit of Excellence on Exercise, Nutrition, and Health (UCEENS); Spanish Ministry of Education, Culture and Sport; Ministerio de Universidades y la Unión Europea–NextGenerationEU; European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska Curie grant, Grant/Award Number: 101028929; CIBEROBN, Centro de Investigación Biomédica en Red (CB22/3/00058), Instituto de

Objective: To examine the associations of self-perceived and objectively-measured physical fitness with psychological well-being and distress indicators in young pediatric cancer survivors.

Materials and Methods: A total of 116 participants (12.1 ± 3.3 years, 56.9% boys) from the iBoneFIT project participated in this cross-sectional study. Objectively-measured physical fitness (muscular fitness) was obtained by handgrip strength and standing long jump tests for the upper and lower body, respectively. Self-perceived physical fitness was obtained by the International Fitness Scale (IFIS). Positive and negative affect were assessed by the positive affect schedule for children (PANAS-C), happiness by Subjective Happiness Scale (SHS), optimism by Life Orientation Test-Revised (LOT-R), self-esteem by the Rosenberg Self-Esteem Scale (RSE), anxiety by State–Trait Anxiety Inventory for Children (STAIC-R), and depression by Children Depression Inventory (CDI). Multiple linear regressions adjusted by key covariates were performed to analyze associations.

Results: No associations were found between objectively-measured muscular fitness and any of the psychological well-being and distress indicators ($p > 0.05$). Self-perceived overall fitness and flexibility were positively associated with positive affect ($\beta \geq 0.258$, $p < 0.05$). Self-perceived cardiorespiratory fitness, speed/

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agility, and flexibility were negatively associated with depression ($\beta \geq -0.222$, $p < 0.05$). Finally, self-perceived cardiorespiratory fitness was also negatively associated with anxiety and negative affect ($\beta \geq -0.264$, $p < 0.05$).

Conclusions: Perceived physical fitness, but not objectively physical fitness, seems to be inversely related to psychological distress variables and to less extent positively related to psychological well-being. The findings from this study highlight the importance of promoting self-perceived fitness in the pediatric oncology population.

KEYWORDS

IFIS and pediatric cancer survivors, physical fitness, psychological health

1 | INTRODUCTION

Childhood cancer is a rare disease but one of the leading causes of death in the childhood population in developed countries.[1] The incidence has increased over the last decades by 13%,[2] despite this, the survival rate of this population has also increased beyond 85%.[3] The main side effects of pediatric cancer and its treatment are obesity, cardiovascular disease, impaired growth, and secondary malignancy.[4–6] Moreover, the psychological sequels are very common in pediatric cancer survivors. For example, a 20% prevalence in anxiety[7] and 2%–40%[8] in depression has been reported in young pediatric cancer survivors, which also affects school absenteeism and fear to future recurrence.[6,9,10]

Childhood and adolescence play a key role in the psychological development. Good mental health is considered a dual-factor construct that comprehends the presence of psychological well-being along with the absence of psychological distress.[11] Psychological well-being is associated with positive thoughts and feelings (i.e., positive affect, happiness, optimism, and self-esteem) while psychological distress is related to negative thoughts and feelings (i.e., anxiety, depression, and negative affect).[12,13] Therefore, strategies to improve psychological health side effects in childhood cancer survivors seem to be required.

Physical fitness is considered an important tool for improving psychological health. Fitness can be measured either self-perceived by self-reported questionnaires or objectively-measured by testing in laboratory or field conditions. The most well-known self-perceived fitness tool is the International Fitness Scale (IFIS),[14] which assesses different fitness components: cardiorespiratory fitness, muscular fitness, speed/agility, and flexibility. Likewise, there are many fitness tests battery to assess fitness in laboratory or field conditions. One of the most used fitness test is the ALPHA battery (Assessing Levels of PHysical Activity), which consists of evaluating cardiorespiratory fitness, muscular fitness, and speed/agility through different reliable and valid tests.[15]

Physical fitness may be associated with better psychological health because people who are physically fit tend to look and feel better, and that makes them associate it with better physical and mental health. In addition, improved fitness can increase some hormones that contribute to mood elevation, such as serotonin.[16] Previous evidence in apparently healthy youths showed that those with better fitness showed also better psychological health.[13,14] In non-healthy young population, fitness has also been considered as a powerful marker of health associated with psychological well-being and distress.[15,16] Previous studies not only in healthy children and adolescents but also in adults with lung cancer observed that greater fitness reduces psychological distress[17,18] and improves psychological well-being indicators.[16,19] However, there is a need for studies to understand the potential contribution of fitness on psychological health variables in young pediatric cancer survivors, whose psychological health is compromised due to the disease itself and the required treatments.

Therefore, the aim of this study was to examine the associations of self-perceived (i.e., overall fitness, cardiorespiratory fitness, muscular fitness, speed/agility, and flexibility) and objectively-measured fitness components (i.e., upper and lower body) with psychological well-being indicators (i.e., positive affect, happiness, optimism, and self-esteem) and psychological distress (i.e., anxiety, depression, and negative affect) in young pediatric cancer survivors.

2 | MATERIALS AND METHODS

2.1 | Study design and participants

A cross-sectional study was conducted within iBoneFIT project framework (https://profith.ugr.es/pages/investigacion/proyectos/ibonefit). A detailed description of the study design and methods has been published elsewhere.[20] In brief, this study included data from 116 children and

adolescents' survivors of pediatric cancer (12.1 ± 3.3 years old; 56.9% boys) from Cordoba and Granada (Spain). Participants of this multicentre study were recruited and measured during Autumn and Winter and in two waves due to COVID-19 restrictions: first, from October to February 2020/2021; and second, a year apart from December to March 2021/2022. This study was approved by the Ethics Committee on Human Research of Regional Government of Andalusia (Reference: 4500, December 2019) and the randomized controlled trial was registered (https://www.isrctn.com/ISRCTN61195625). A signed informed consent was obtained from all participants prior to data collection.

2.2 | Body composition, maturity, and clinical data

Height (cm) was evaluated with a precision stadiometer (SECA 225, Hamburg, Germany) to the nearest 0.1 cm. An electronic scale (SECA 861, Hamburg, Germany) with an accuracy of 100 g was used to measure body mass (kg). Body mass index was calculated as body mass (kg)/height (m^2). Years from peak height velocity (PHV) was used as a somatic maturational landmark.[21] PHV is the period of maximum growth in stature, and years from PHV are considered in terms of time before and after the PHV. It was predicted using age and height in a validated algorithm in children.[21] In addition, the time (years) between diagnosis to testing and the type of neoplasm was obtained from clinical records.

2.3 | Physical fitness

The ALPHA fitness test battery was used to assess fitness objectively. These fitness tests have been demonstrated to be valid, reliable, and health-related in children and adolescents.[15] Cardiorespiratory fitness and speed/agility were expected to be measured by 20 m shuttle run and 4 × 10 m shuttle run tests. However, due to the pandemic situation during the evaluation time, the use of face masks was mandatory by the National Health Authorities. After internal discussions, we finally decided to exclude the cardiorespiratory fitness and speed/agility test because the available evidence at that time showed impaired performance using FFP2/N95 face masks,[22] and more importantly, to ensure the safety of our participants. Muscular fitness for the upper and lower body was assessed with the handgrip strength (TKK 5101 Grip D, Takey, Tokyo Japan) and standing long jump tests, respectively. The handgrip was performed twice on each hand and the best value was chosen and averaged, while the best of two attempts was retained for the standing long jump. The ALPHA fitness test battery protocol was followed and a 1-minute rest was allowed between handgrip measures of the same hand.

Self-perceived fitness was assessed by using the IFIS, which is known to be valid in young populations.[14] This tool is composed of 5-items (i.e., overall fitness, cardiorespiratory fitness, muscular fitness, speed/agility, and flexibility) about the fitness perception of the participants compared with their friends. It includes 5 possible answers (i.e., very bad, bad, acceptable, good, and very good).

2.4 | Psychological health

Psychological health was assessed through self-perceived questionnaires based on the following dimensions and focusing on the factors that best explain the mental health status of children and adolescents[11]: psychological well-being (i.e., positive affect, happiness, optimism, and self-esteem) and psychological distress (i.e., anxiety, depression, and negative affect).

Self-esteem, which refers to how we assess our-self whether positively or negatively, was evaluated with the Rosenberg Self-Esteem scale that it is validated in children and adolescents.[23] This scale has 10 items that assess global self-esteem considering both positive and negative feelings with 4 possible answers (i.e. totally disagree, disagree, agree, and totally agree).[24] The final score ranges from 10 (lowest self-esteem) to 40 (highest self-esteem). Dispositional optimism, which refers to how favorably people view their future, was evaluated with the Life Orientation Test-Revised (LOT-R) using 6 items (out of 10) with 5 possible answers (totally disagree, disagree, neither disagree nor agree, agree, and totally agree).[25] The score ranges from 6 (lowest optimism) to 30 (highest optimism). Happiness, which refers to positive psychological functioning, was assessed by the Subjective Happiness Scale (SHS) whose Spanish version has shown appropriate test–retest reliability, internal consistency, and convergent validity.[26] This tool includes 4 items in a Likert scale ranging from 1 to 7 (from less happiness to more happiness) The score was calculated as the sum of the 3 first items with a range from 3 (lowest happiness) to 21 (highest happiness).

Positive affect, which is defined as the perception of emotion in a good or positive way and negative affect, defined as the tendency to experience negative feelings, was measured with the Positive Affect Schedule for children (PANAS-C) in 20 items (10 for positive affect; 10 negative affect) with 3 possible answers (never, sometimes and many times).[27] The final score was calculated as the sum of 10 items (for either negative or positive affect) and it ranges from 10 (lowest negative or positive affect) to 30 (highest negative or positive affect).

Childhood anxiety, which refers to the brain's state of alertness to worry or fear, was assessed with the State–Trait Anxiety Inventory for Children (STAIC-T). This inventory has been extensively validated in Spanish children.[28] This tool collects 20 items with 3 possible answers (rarely, sometimes, and often) and a score range from 20 (lowest anxiety level) to 60 points (highest anxiety level). Depression, which means a low or apathetic mood over time, was measured with the Children Depression Inventory (CDI), which consists of 27 items assessing 5 domains (interpersonal problems, ineffectiveness, negative mood, anhedonia, and negative self-esteem) with three types of answer depending on the intensity of the selected symptoms, rated with a score of 0–2.[29] The score ranges from 0 (lowest depression level) to 54 (highest depression level).

2.5 | Statistical analysis

Descriptive characteristics of the study sample were computed as mean and standard deviation or percentages for continuous and categorical variables, respectively. All variables were checked for normality using both graphical (normal probability plots) and statistical (Kolmogorov–Smirnov test) procedures. There was no interaction between sex and fitness variables in relation to psychological health variables and therefore, the analyses were performed including boys and girls together.

Partial correlations adjusted by key confounders (i.e., sex, years from PHV, years between diagnosis and testing, body mass index, and type of neoplasm) were used to examine how the fitness components or psychological health indicators correlated to each other. The associations between fitness (i.e., objectively-measured and self-perceived) with psychological health (i.e., well-being and distress) were performed using multiple linear regression and adjusted by the previous covariates.

Additionally, differences in psychological well-being and psychological distress by fitness levels (low fitness vs. high fitness) were obtained by one-way analysis of covariance and adjusting for the same set of covariates. This analysis was performed for those significant associations reported in the multiple linear regressions. Children were grouped in the "low fitness" group when they perceived very bad and bad fitness levels in the IFIS (equivalent to <P10th) and in the "high fitness" group when they perceived good-very good fitness level (equivalent to ≥P30th).[30] In this specific analysis, we excluded children who answered "average" to have both end extremes (i.e., low and high).

All the analyses were performed using the IBM SPSS Statistics for Windows version 22.0 (IBM Corp), and the level of significance was set to $p < 0.05$.

3 | RESULTS

Table 1 shows descriptive data on anthropometric characteristics, demographic characteristics, somatic maturation, clinical data, fitness, and psychological health variables in all participants and by sex.

Table S1 shows partial correlation coefficients between the fitness components. Overall, objectively-measured muscular fitness correlated with self-perceived overall fitness, muscular fitness, and speed/agility (r from 0.202 to 0.353, all $p < 0.05$). Moreover, most self-perceived fitness indicators correlated to each other (r from 0.256 to 0.550, all $p < 0.05$), except for the associations between flexibility with muscular strength ($r = 0.084$, $p = 0.397$) and speed/agility ($r = 0.185$, $p = 0.061$) and, cardiorespiratory fitness with muscular strength ($r = 0.163$, $p = 0.099$) Table S2 shows partial correlation coefficients between the psychological health indicators. All psychological well-being and distress indicators correlated to each other (r from −0.252 to 0.671, all $p < 0.05$), except for the association between negative and positive affect ($r = -0.132$, $p = 0.194$).

Table 2 shows multiple linear regression between fitness (i.e., objectively-measured and self-perceived) and psychological health (i.e., well-being and psychological distress dimensions) adjusted by sex, years from PHV, years between diagnosis and testing, body mass index and type of neoplasm. Objectively-measured muscular fitness was not associated with any of the psychological well-being and psychological distress indicators analyzed (standardized beta, $\beta \leq -0.271$, all $p > 0.05$). Self-perceived overall fitness and flexibility were positively related to positive affect ($\beta \geq 258$, all $p < 0.05$). Self-perceived cardiorespiratory fitness, speed/agility, and flexibility were negatively associated with depression ($\beta \geq -0.222$, $p < 0.05$). Self-perceived cardiorespiratory fitness was also negatively associated with anxiety and negative affect ($\beta \geq -0.264$, $p < 0.05$). No significant associations were observed in the remaining self-perceived fitness and psychological health variables studied (all $p > 0.05$).

We explored whether those children categorized as "high fitness" presented greater psychological health than their peers grouped as "low fitness." For this purpose, only significant associations previously described were analyzed (see Figure 1). We observed that high-fit participants in cardiorespiratory fitness presented lower anxiety, negative affect, and depression levels (all $p <= 0.008$) compared with those peers in the low-fit group. Moreover, high-fit participants in speed/agility had lower depression levels ($p = 0.013$) compared with low-fit participants. Finally, participants categorized in the high-fit group in flexibility had greater positive affect ($p = 0.010$) than those in the low-fit group.

TABLE 1 Descriptive characteristic of the study sample by sex.

	N	Total	*N*	Boys	*N*	Girls
Age (years)	116	12.1 ± 3.3	66	12.0 ± 3.2	50	12.2 ± 3.0
Weight (kg)	116	46.6 ± 18.0	66	47.1 ± 17.4	50	46.0 ± 19.0
Height (cm)	116	147.5 ± 17.1	66	148.8 ± 17.8	50	145.6 ± 16.0
Body mass index (kg/m^2)	116	20.7 ± 4.7	66	20.5 ± 4.1	50	20.9 ± 5.3
Years from PHV	116	−0.7 ± 2.7	66	−1.3 ± 2.5	50	0.0 ± 2.9
Years from diagnosis to testing	110	6.4 ± 3.9	62	6.4 ± 3.9	48	6.6 ± 3.8
Type of neoplasm (%)						
Soft	70	60.9	41	63.1	29	58
Solid	45	39.1	24	36.9	21	42
Objectively-measured fitness						
Absolute upper-body muscular strength (kg)	116	18.1 ± 8.6	66	19.4 ± 10.0	50	16.3 ± 5.9
Relative lower-body muscular strength (cm)	115	118.1 ± 33.1	65	127.1 ± 35.8	50	106.4 ± 25.0
Self-perceived fitness (very low, low, average, high, very high; %)						
Overall fitness	114	1, 10, 32, 41, 16	64	2, 8, 34, 39, 17	50	0, 12, 30, 44, 14
Cardiorespiratory fitness	114	3, 18, 40, 29, 10	64	2, 15, 42, 30, 11	50	4, 22, 38, 28, 8
Muscular strength	114	0, 13, 42, 28, 17	64	0, 14, 36, 33, 17	50	0, 13, 42, 28, 17
Speed/agility	114	2, 18, 30, 31, 19	64	3, 19, 25, 34, 19	50	0, 18, 36, 26, 20
Flexibility	114	9, 18, 34, 32, 7	64	10, 17, 42, 28, 3	50	8, 20, 24, 36, 12
Psychological well-being						
Positive affect (PANAS-C)	111	24.7 ± 3.3	62	24.8 ± 3.5	49	24.5 ± 3.0
Happiness (SHS)	110	22.5 ± 4.5	62	23.1 ± 4.3	48	21.8 ± 4.7
Optimism (LOT-R)	111	21.9 ± 4.2	62	22.3 ± 4.3	49	21.5 ± 4.1
Self-esteem (RSE)	111	27.7 ± 2.4	62	27.8 ± 2.4	49	27.4 ± 2.3
Psychological distress						
Anxiety (STAIC-R)	111	32.3 ± 6.6	62	31.7 ± 6.4	49	33.1 ± 6.8
Depression (CDI)	113	10.2 ± 5.9	65	10.5 ± 6.0	48	9.8 ± 5.8
Negative affect (PANAS-C)	111	17.9 ± 3.4	62	17.8 ± 3.4	49	18.1 ± 3.5

Note: Values are mean ± standard deviation or percentages. Analyses adjusted for sex, years from peak high velocity, years between diagnosis and testing, body mass index, and type of neoplasm.

Abbreviations: CDI, Children Depression Inventory (score ranges from 0 to 54); LOT-R, Life Orientation Test-Revised (score ranges from 6 to 30); PANAS-C, Positive and Negative Affect Scale for Children (score ranges from 10 to 30); PHV, peak height velocity; RSE, the Rosenberg Self-Esteem Scale (score ranges from 10 to 40); SHS, Subjective Happiness Scale (score ranges from 3 to 21); STAIC-R, State–Trait Anxiety Inventory for Children (score ranges from 20 to 60).

4 | DISCUSSION

The present study shows the associations between self-perceived and objectively-measured muscular fitness and psychological well-being and psychological distress indicators in young pediatric cancer survivors. The main findings of this study are: (i) self-perceived overall fitness and flexibility were positively associated with positive affect; and (ii) self-perceived cardiorespiratory fitness, speed/agility, and flexibility were negatively associated with anxiety, depression, and negative affect, respectively. No significant associations were observed between objectively-measured muscular fitness and any of the psychological well-being and psychological distress indicators analyzed.

4.1 | Psychological well-being

In our study, self-perceived overall fitness and flexibility were positively associated with positive affect. The lack of studies investigating this association between cancer population and healthy youths[31] limits the comparisons among studies. Looking at intervention studies, Kolden et al.[32]

TABLE 2 Multiple linear regression models analyzing the associations between physical fitness (i.e., objectively-measured and self-perceived) and psychological health (i.e., well-being and distress indicators) in young pediatric cancer survivors.

	Psychological well-being				Psychological distress		
	Positive Affect (PANAS-C)	**Happiness (SHS)**	**Optimism (LOT-R)**	**Self-Esteem (RSE)**	**Anxiety (STAIC-R)**	**Depression (CDI)**	**Negative Affect (PANAS-C)**
Objectively-measured[a]							
Absolute upper-body muscular strength (kg)	−0.102	−0.226	−0.188	−0.271	0.048	0.061	0.069
Relative lower-body muscular strength (cm)	0.115	−0.081	−0.060	−0.122	0.024	−0.146	0.166
Self-perceived (IFIS)							
Overall fitness	**0.266***	0.185	0.181	0.135	−0.098	−0.206	−0.051
Cardiorespiratory fitness	0.131	0.092	0.132	0.172	**−0.317***	**−0.236***	**−0.264***
Muscular strength	0.188	0.178	0.182	0.106	−0.087	−0.144	−0.048
Speed/agility	0.167	0.147	0.103	0.146	−0.112	**−0.222***	−0.118
Flexibility	**0.258***	0.086	0.135	0.161	−0.087	**−0.265***	0.054

Note: Values represent standardized coefficient. Statistically significant values are highlighted in bold. *$p < 0.05$ denotes statistically significant.

Abbreviations: CDI, Children Depression Inventory; IFIS, International Fitness Scale; LOT-R, Life Orientation Test-Revised; PANAS-C, Positive and Negative Affect Scale for Children; RSE, The Rosenberg Self-Esteem Scale; SHS, Subjective Happiness Scale; STAIC-R, State–Trait Anxiety Inventory for Children.

[a]Cardiorespiratory fitness and speed/agility tests were not performed during COVID-19 pandemic because of the available evidence at that time showing impaired performance using FFP2/N95 face masks[28] and, more importantly, to ensure the safety of our participants.

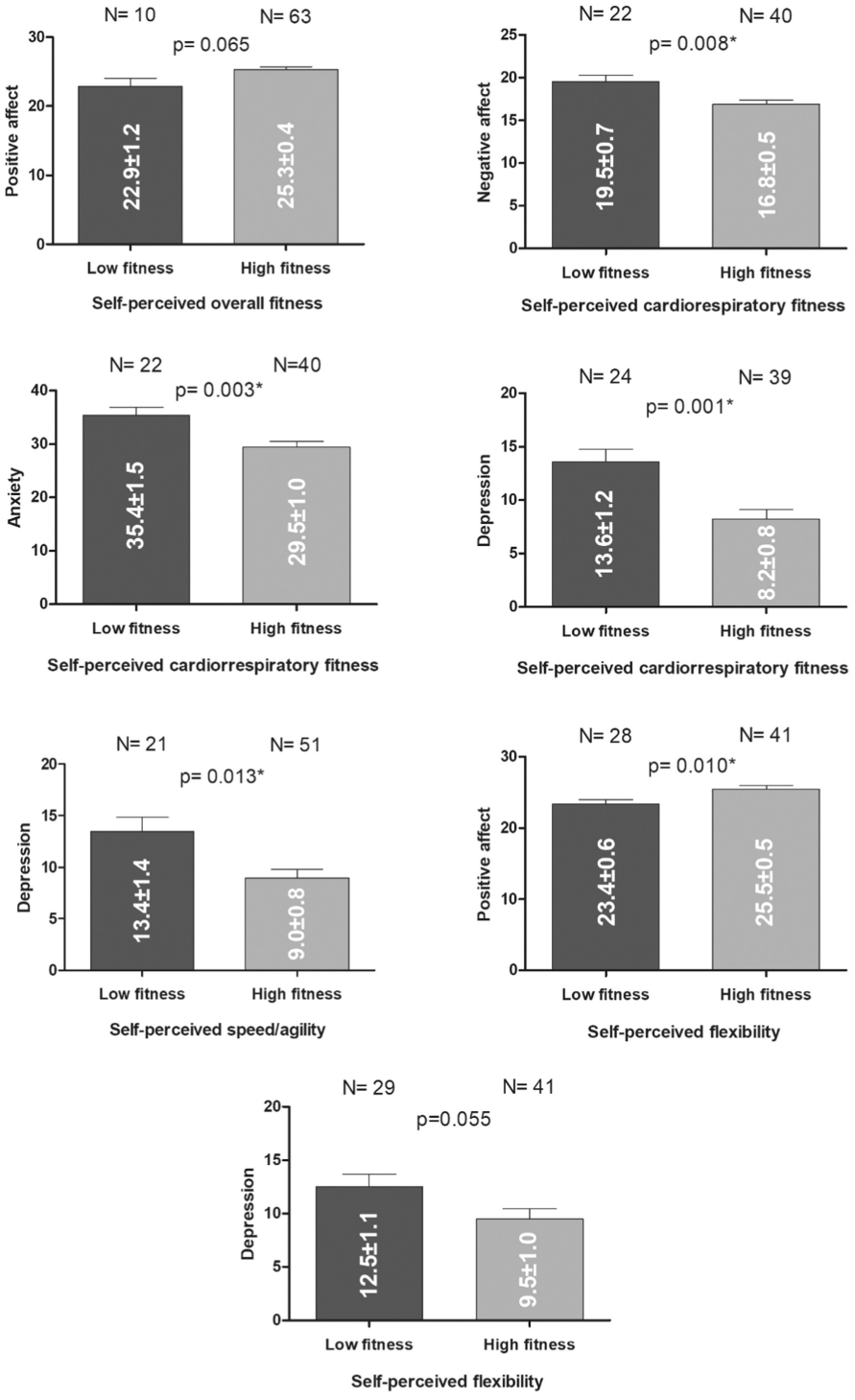

FIGURE 1 One-way analysis of covariance examining differences in psychological well-being and distress indicators (i.e., positive and negative affect, anxiety, and depression) by self-perceived fitness levels (low/high) and adjusted for sex, years from peak high velocity, years between diagnosis and testing, body mass index, and type of neoplasm in young pediatric cancer survivors. *p* shows differences between groups (i.e., low fitness vs. high fitness). Low fitness group includes participants with very poor and poor fitness and high fitness includes participants with high and very high fitness in the IFIS. Values show as mean ± standard error.

showed that a multicomponent exercise intervention (including flexibility exercises) improved positive affect, albeit in breast cancer patients.[32] A plausible explanation could be due to the exercise capacity on reducing cortisol levels,[33] which in turn, could improve the psychological well-being. In this line, two main systematic reviews and meta-analyses showed that physical activity has a potential role on improving psychological health and physical fitness in children and adolescents.[31,34] In relation to the objective measures of fitness, no associations were found between upper- and lower-body muscular fitness with any of the psychological well-being indicators. Although there is no evidence focusing on cancer survivors (either pediatric or non-pediatric), a recent systematic review and meta-analyses in children and adolescents depicted that muscular fitness was positively related to psychological well-being indicators (i.e., self-esteem, self-concept, and physical self-perceptions).[31,35] These associations between muscular fitness and self-esteem may be due to the increase in lean mass resulting from resistance training and

also because of the neurochemical effects of fitness in the brain that elevate mood.[16] However, in our study, these associations were not found nor even using the same tool, perhaps due to the different populations studied and the treatment- and cancer-related sequels as shown by their different levels of self-esteem (e.g., Rodriguez-Ayllon et al.[36]: mean ± SD of 33.1 ± 4.7 vs. 27.66 ± 2.37 in the present study). In addition, some studies have found that adolescents with higher fitness levels tend to exercise in a social context, which may increase feelings of total acceptance.[37] Cancer survivors, being a vulnerable population, tend to exercise individually, which may explain the lack of significant results between objectively-measured and some indicators of psychological health. In this study, we could not measure cardiorespiratory fitness objectively, but previous evidence in adolescents with overweight/obesity found that improving cardiorespiratory fitness was associated with better self-esteem, which may be due to changes in brain structure and brain signaling.[38] The lack of studies investigating these associations in oncology population makes it hard to explain the potential mechanisms behind the lack of association found in this manuscript, but it might be plausible that cardiorespiratory fitness does not influence psychological well-being outcomes in the same manner as it does with psychological distress indicators. Future studies with longitudinal design and using objective measures of fitness are needed in this population.

4.2 | Psychological distress

We found that self-perceived cardiorespiratory fitness, the most consistent fitness component, was negatively associated with psychological distress indicators such as anxiety, depression, and negative affect. Moreover, speed/agility, and flexibility were also negatively associated with depression, that is, the better the perception of the speed/agility, and flexibility levels, the lower the depression levels. As with psychological well-being indicators, studies investigating this association in young pediatric cancer survivors are lacking, and therefore, other populations are used to discuss our findings. Our findings agree with those reported by a systematic review and meta-analysis by Cadenas-Sanchez et al.[31] who observed that adolescents who presented lower cardiorespiratory fitness reported elevated depressive symptoms. The plausible explanation might shed light on the role of aerobic and resistance training on psychological health through increasing oxygen transport and brain blood flow.[31] Although we could not measure cardiorespiratory fitness objectively, a previous study in childhood survivors of acute lymphoblastic leukemia found cardiorespiratory fitness to protect against depression,[39] which is in line with our perceived fitness findings. Regarding objective fitness, no associations were found between muscular fitness and any of the psychological distress indicators, supporting the lack of association that we observed when using self-perceived muscular fitness instead. Our findings are partially in agreement with a recent systematic review and meta-analyses in which the authors did not observe a significant association between muscular fitness and depression (pooled correlation −0.047, 95% confidence intervals: −0.110, 0.016); but they observed a pooled significant correlation between muscular fitness and anxiety (pooled correlation −0.176, 95% confidence intervals: −0.306, −0.040). Additionally, research in children with overweight/obesity showed that upper body muscular fitness and negative affect were inversely associated.[36] Differences between our findings and the previous evidence could be due to the lower fitness and higher psychological distress levels in our sample with cancer survivors, than in those children apparently healthy or with overweight/obesity. As an example, we have observed that the negative affect (using the same questionnaire) was lower in children with overweight/obesity than in pediatric cancer survivors (ActiveBrains: 16 ± 3.4 vs. iBoneFit: 17.9 ± 3.4).

4.3 | Strengths and limitations

To our knowledge, this is the first study using both objective and self-perceived fitness assessments to examine its association with psychological health in this population. Moreover, our findings have been controlled for covariates that are known to affect psychological health in this population. Nevertheless, there are some limitations that should be noted. Firstly, being a cross-sectional study, it does not allow us to infer causality for any of the association factors, so further longitudinal studies are needed to confirm these findings. Moreover, although we have controlled for potential confounders, there may be other variables that could interfere with these associations. Some objective fitness tests (cardiorespiratory and speed/agility) could not be carried out due to the mandatory use of face masks (due to covid-19 pandemic) as these could affect the measures. Nevertheless, the participants and their families were grateful not to do these tests due to increased contagion risk and the uncertain consequences this could have had in this sensitive population.

5 | CONCLUSION

Overall, our study indicates that higher self-perceived overall fitness and flexibility are associated with better psychological well-being (i.e., positive affect). Moreover,

greater self-perceived cardiorespiratory fitness, speed/agility, and flexibility but not muscular fitness (neither self-perceived nor objectively-measured) is associated with lower psychological distress (i.e., anxiety, depression, and negative affect). The findings from this study highlight the importance of promoting self-perceived fitness in the pediatric oncology population.

6 | PERSPECTIVE

Assessing psychological health after childhood cancer is important as it affects many areas such as school attendance and adherence to physical activity. Psychological health variables have hardly been studied nor related to exercise in young pediatric cancer survivors; however, some studies have looked at levels of anxiety and depression in this population. Likewise, fitness is usually measured only objectively; however, validated questionnaires are available that allow a quick assessment that facilitates the collection of this data. Given that some articles have observed that good fitness levels are related to better psychological health in healthy young, more studies examining both psychological well-being and distress in young pediatric cancer survivors are needed.

ACKNOWLEDGEMENTS

We would also like to thank the collaboration with the Hospital Virgen de las Nieves in Granada and Reina Sofia in Cordoba and all the professionals and families who have participated in the investigation.

FUNDING INFORMATION

This study has been partially supported by the Spanish Ministry of Science and Innovation (ref: PID2020-117302RA-I00), La Caixa Foundation (ref: LCF/BQ/PR19/11700007), the University of Granada Plan Propio de Investigación 2021—Excellence actions: Unit of Excellence on Exercise, Nutrition, and Health (UCEENS) and by CIBEROBN, Centro de Investigación Biomédica en Red (CB22/3/00058), Instituto de Salud Carlos III, Ministerio de Ciencia e Innovación and Unión Europea - European Regional Development Fund. AM-P is the recipient of a predoctoral fellowship (FPU20/05530) from the Spanish Ministry of Education, Culture and Sport. EUG is supported by the Maria Zambrano fellowship by the Ministerio de Universidades y la Unión Europea–NextGenerationEU. C.C.-S. is supported by a grant from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska Curie grant agreement No 101028929. Funding for open access charge: Universidad de Granada/CBUA.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

PATIENT CONSENT STATEMENT

A signed informed consent was obtained from all participants prior to data collection.

PERMISSION TO REPRODUCE MATERIAL FROM OTHER SOURCES

Not applicable.

CLINICAL TRIAL REGISTRATION

https://www.isrctn.com/ISRCTN61195625.

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How to cite this article: Rodriguez-Solana A, Gracia-Marco L, Llorente-Cantarero FJ, et al. Is higher physical fitness associated with better psychological health in young pediatric cancer survivors? A cross-sectional study from the iBoneFIT project. *Scand J Med Sci Sports*. 2023;00:1-11. doi:10.1111/sms.14345