

PILOTING A PSYCHOLOGICAL NEED-SUPPORT CENTERED LIFESTYLE PROGRAM
TO TREAT PEDIATRIC OVERWEIGHT AND OBESITY AMONG HISPANIC
ADOLESCENTS

by

Yangyang Deng

(Under the Direction of Sami Yli-Piipari)

ABSTRACT

This dissertation aimed to quantify the effects of randomized controlled trial (RCT) pediatric lifestyle interventions in treating childhood obesity. An additional aim of the dissertation was to examine the efficacy of the BRAVO!, the psychological need-support centered lifestyle intervention, on participants' body composition and health-related fitness.

A systematic review and meta-analysis were conducted to determine the efficacy of RCT pediatric lifestyle interventions in treating obesity among 11- to 17-year-old children. The primary outcome variables were body mass index (BMI), standardized BMI (BMIz), and waist circumference (WC). The results showed that pediatric lifestyle interventions were moderately effective in improving overweight and obese children's BMI (-1.77 kg/m², 95% CI [-2.65, -.88], $p < .001$), BMIz (-.30, 95% CI [-.44, -.17], $p < .001$), and WC (-3.72 cm, 95% CI [-5.59, -1.85], $p < .001$). In addition, moderation analyses suggested that lifestyle interventions were the most effective when participants were 13 to 15 years old and at the higher end of the obesity spectrum.

Furthermore, to test the efficacy of psychological need-support centered lifestyle intervention BRAVO!, an RCT was conducted with a sample of 40 pediatrician-referred

participants ($M_{\text{age}} = 13.20 \pm 1.54$) allocated to two parallel arms: 1) BRAVO! ($n = 20$) and b) “usual care” ($n = 20$). The 12-week BRAVO! consisted of 24 exercise sessions (twice/week, 60min/session) and family-based nutrition classes (once/week, 30min/session) and psychological need-support-centered behavior modification. The results showed that BRAVO! was efficacious in generating positive changes in participants’ BMI ($F[1, 31] = 23.83, p < .001, \eta^2 = .45$), WC ($F[1, 31] = 26.58, p < .001, \eta^2 = .48$), cardiovascular endurance ($F[1,31] = 8.18, p = .008, \eta^2 = .23$), upper body ($F[1, 31] = 28.33, p < .001, \eta^2 = .50$), and abdominal muscular strength/endurance ($F[1, 31] = 28.34, p < .001, \eta^2 = .45$). The changes in cardiovascular endurance vanished over time, but the changes in BMI, WC, upper body muscular and abdominal muscular strength/endurance remained for a longer term. Conclusions: BRAVO! lifestyle program was efficacious in improving at-risk Hispanic children’s body composition and health-related fitness, behavioral, and psychological outcomes in the short and longer term.

INDEX WORDS: Overweight, weight gain, childhood, intervention, self-determination theory, intrinsic motivation, meta-analysis

PILOTING A PSYCHOLOGICAL NEED-SUPPORT CENTERED LIFESTYLE PROGRAM
TO TREAT PEDIATRIC OVERWEIGHT AND OBESITY AMONG HISPANIC
ADOLESCENTS

by

Yangyang Deng

BS. Shanghai University of Sport, China, 2011

MS. The University of North Carolina at Greensboro, United States, 2018

MS. The University of Georgia, United States, 2021

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial
Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2022

© 2022

Yangyang Deng

All Rights Reserved

PILOTING A PSYCHOLOGICAL NEED-SUPPORT CENTERED LIFESTYLE PROGRAM
TO TREAT PEDIATRIC OVERWEIGHT AND OBESITY AMONG HISPANIC
ADOLESCENTS

by

Yangyang Deng

Major Professor:	Sami Yli-Piipari
Committee:	Michael D. Schmidt
	Sarah T. Henes

Electronic Version Approved:

Ron Walcott
Dean of the Graduate School
The University of Georgia
August 2022

DEDICATION

To Tomorrow

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to these persons who have given their invaluable support and assistance to my research while pursuing my Ph.D. studies. It is hardly impossible for me to achieve this milestone without their direct and indirect support.

I would like to express my utmost gratitude to my supervisor, Dr. Sami Yli-Piipari, for the time and effort he put into my professional development; For all the valuable advice and support he provided for my research, and continued to have faith in me over the years. Under his guidance, patience, and support, I learned to be an independent and highly motivated scholar. Many thanks to my committee member, Dr. Michael D. Schmidt, and Dr. Sarah T. Henes. For their expertise, academic insights, and professional guidance they provided in this dissertation research. I wish to express my gratitude to Dr. Patrick J. O’Conner and Dr. Abhyuday Mandal for providing me support for my research career development. I want to give my special thanks to my former advisor, Dr. Ang Chen, for the important lessons he has taught me during my master's study, and my undergraduate advisor, Dr. Dong Zhu, for kindly encouraging me to pursue my academic study.

I want to thank all the graduate students, faculty, and staff of the department of kinesiology at the University of Georgia. I appreciate the great research environment that the Kinesiology department created and I was encouraged to be a productive scholar. Special thanks to my lab member, Dr. Mika Manninen, Yongju Huang, and Taewoo Kim, your assistance and support made the data collection procedure easier. Special thanks to my friends, Dr. Xiaoxia Zhang, Zhaiming Shen, and Ruchkia Bansal, I appreciate all the valuable emotional support.

Last, I am greatly indebted to my parents; their unconditional love, care, and tolerance always impact and inspire me to be a wise person.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS.....	iv
LIST OF TABLES.....	x
LIST OF FIGURES	xi
CHAPTER	
1 INTRODUCTION	1
Problem Statement and Significance of Study.....	1
Research Questions.....	5
Summary of the Studies	7
Public Health Significance.....	7
Definitions of Key Terms	8
References	10
2 LITERATURE REVIEW	15
Etiology of Obesity.....	15
Factors Contributing to Obesity in Youth.....	17
The Role of Motivation in Healthy Weight and Lifestyle	23
Lifestyle Interventions	24
Efficacy of Lifestyle Interventions	26
The Present Dissertation Research.....	35
References	38

3	EFFICACY OF LIFESTYLE INTERVENTIONS TO TREAT PEDIATRIC OBESITY: A SYSTEMATIC REVIEW AND META-ANALYSIS	47
	Abstract	48
	Introduction.....	49
	Methods.....	52
	Results.....	55
	Discussion	59
	Conclusion	63
	References	64
4	PSYCHOLOGICAL NEED-SUPPORT CENTERED LIFESTYLE PROGRAM TO TREAT PEDIATRIC OBESITY AMONG HISPANIC ADOLESCENTS; A RANDOMIZED CONTROLLED TRIAL.....	88
	Abstract	88
	Introduction.....	91
	Methods.....	96
	Results.....	104
	Discussion	110
	Conclusion	117
	References	118
5	CONCLUSIONS.....	134
	Primary Conclusion	134

Strength and Limitations	138
Conclusion	140
Future Research	140

APPENDICES

A CONSENT FORM.....	147
B ASSENT FORM	148
C SCREENING FORM.....	150
D DIET RECALL.....	154
E FITNESS TEST	158
F EXERCISE REGUALTIONS QUESTIONNAIRE	161
G RATINGS OF PERCEIVED EXERTION SCALE	163
H BACKGROUND QUESTIONNAIRE	164
I SATISFACTION WITH LIFE SCALE QUESTIONNAIRE	165
J REVISED COCHRANE RISK-OF-BIAS TOOL	166

LIST OF TABLES

	Page
Table 3.1. Characteristics of included studies: results for BMI, BMIZ and WC outcomes.....	70
Table 3.2. Risk of bias summary for bias within included studies	74
Table 3.3. Univariate moderator analysis BMI and WC	76
Table 4.1. Summary of effect size on outcome measures.....	122
Table 4.2. Intervention content outlines	124
Table 4.3. Need-supportive motivational strategies	127
Table 4.4. Baseline participants characteristics	128
Table 4.5. Characteristics of the study variables	129
Table 4.6. Between groups difference	130

LIST OF FIGURES

	Page
Figure 3.1. PRISMA 2020 flow diagram.....	77
Figure 3.2. Forest plots for BMI	78
Figure 3.3. Forest plots for BMIz	79
Figure 3.4. Forest plots for WC	80
Figure 3.5. Funnel plot for risk of publication bias	81
Figure 3.6. Contour-enhanced funnel plot for risk of publication bias.....	82
Figure 4.1. BRAVO lifestyle program recruitment process and flowchart	131
Figure 4.2. BMI and WC changes across the time	132
Figure 4.3. Changes in health-related fitness variables across the time	133

CHAPTER I

INTRODUCTION

1.1 Problem Statement and Significance of Study

Obesity is a public health problem associated with elevated risks of chronic diseases, e.g., type 2 diabetes mellitus, metabolic syndrome, and cardiovascular diseases (Cardel, Atkinson, Taveras, Holm, & Kelly, 2020; Goodman & Whitaker, 2002; Rankin et al., 2016). Childhood and adolescent obesity are also associated with a myriad of adverse psychological effects, e.g., depression, low perceived health-related quality of life, emotional and behavioral disorders, body dissatisfaction, and low self-esteem (Sahoo et al., 2015; Swallen, Reither, Haas, & Meier, 2005). The prevalence of pediatric obesity in the United States (US) is a problem, with almost 20% (14.7M) of US children being obese (Stierman et al., 2021). This is highly problematic as the early development of overweight and obesity in children and adolescents increases the risk of obesity in adulthood (Bond et al., 2015; Craigie et al., 2009; Dietz et al., 2007). It is predicted that if all of the obese 14.7 million children and adolescents in the US became obese adults, the costs for treatment might be over \$1.1 trillion during their lifetimes (Kasman, Hammond, Werman, Mack-Crane, & McKinnon, 2015).

In recent decades, childhood and adolescent overweight and obesity have become increasingly prevalent in underserved populations (Styne et al., 2017). Pediatric obesity is strongly linked to low socioeconomic and minority status (Ogden et al., 2018). It is reported (Stierman et al., 2021) that Hispanic children (25.8%) and Black children (22.0%) are around

1.5-1.8 times more likely to be overweight than non-Hispanic White children (14.1%). Notably, Hispanic children have the highest obesity rate of all racial/ethnic groups. Given that Hispanic adolescents (12-19 years old) are becoming one of the fastest-growing pediatric obesity populations, designing and implementing the effective program to treat overweight and obesity is a critical public health need.

Adolescence is a complex life stage, with youth experiencing biological, hormonal, and physical changes. The pubertal period is associated with a significant change in height and weight. Given that healthy nutrition, physical activity (PA), and exercise are vital for adolescents' growth, poor diet quality, overeating problems, and low levels of regular PA are the primary factors contributing to obesity, and other chronic diseases (Lassi, Moin, Das, Salam, & Bhutta, 2017). Several strategies e.g., pharmacotherapy, bariatric surgery, and combinations of these strategies are recognized as well-established treatment plans for obesity (Maggard et al., 2005). Although medical advances combining medication and surgeries have been shown to be effective, these treatments are invasive and not recommended for pediatric populations (Styne et al., 2017). For example, bariatric surgery is normally advised for people older than 18 years old (Mechanick et al., 2013). In addition, these clinical procedures, e.g., bariatric surgeries and endoscopic procedures, are expensive and largely not available for underserved patients. Hence, the need for novel and effective strategies to treat overweight and obesity in underserved adolescents is urgent.

Lifestyle programs refer to the combination of diet, exercise, and behavior modification, and they are regarded as a non-invasive strategy to treat childhood obesity (Psaltopoulou et al., 2019; Styne et al., 2017). It can include one single intervention component, e.g., exercise or diet,

or a combination of several components. Evidence suggests that compared to a single intervention approach (e.g., either diet or exercise), combined exercise and diet interventions have better efficacy in treating obesity in children and adolescents (Brown et al., 2019; Ho et al., 2013). Moreover, lifestyle interventions are normally preferred options to treat childhood obesity as clinical procedures are invasive and costly.

Several meta-analyses have reported that lifestyle interventions can be effective in improving children and adolescents' weight status, BMI, WC, and reducing numerous weight-related risk factors, e.g., low-density lipoprotein and fasting insulin (Berge & Everts, 2011; Deng et al., in review; Ho et al., 2012; Luckner, Moss, & Gericke 2012; Peirson et al., 2015; Salam et al., 2020; Stoner et al., 2016). The published meta-analyses have shown pediatric lifestyle interventions to be effective in improving participants' BMI, with the effect sizes ranging from $-.09 \text{ kg/m}^2$ (95% CI $[-.16, -.03]$; Luckner, Moss, & Gericke, 2012) to -2.00 kg/m^2 (95% CI $[-1.5, -2.5]$; Stoner et al., 2016). Despite the small-to-moderate sized effects, the reviews demonstrate that there is large heterogeneity in the lifestyle intervention effect sizes, suggesting that although some interventions are effective some are not.

It is well-known that poor physical fitness contributes to unhealthy BMI (Jackicic et al., 2019). Interestingly, recent evidence suggests that childhood lifestyle interventions should focus on improving children's cardiovascular and muscle health rather than focusing solely on weight status or body composition (Mayr, Cohen, Isenring, Soenen, & Marshall, 2020; Friedemann, Heneghan, & Ward, 2015). Despite this, a majority of the pediatric lifestyle interventions have focused on weight and body composition and less on children's cardiovascular and muscular

health (Joschtel et al., 2018; Lesinski, Herz, Schmelcher, & Granacher, 2020; Moncada-Jiménez & Carazo-Vargas, 2015; Yang, Qiu, & Luo, 2021).

The current literature suggests that there is a need to further understand the conditions which improve the effectiveness of pediatric lifestyle interventions in improving body composition of underserved adolescents (Berge & Everts, 2011; Deng et al., in review; Ho et al., 2012; Luckner, Moss, & Gericke 2012; Peirson et al., 2015; Salam et al., 2020; Stoner et al., 2016). In this dissertation research, the focus will be on two major gaps in this literature. First, although previous research has shown pediatric lifestyle interventions to be effective in producing small-to-moderate effects in body composition (e.g., BMI; Hedge's $g = .25-.47$) in children and adolescents (Kobes, Kretschmer, & Schreuder, 2018; Ranucci et al., 2017), there is a large heterogeneity in the efficacy of these lifestyle interventions. This is primarily due to variability in the lifestyle program's intervention designs, i.e., length, frequency, and content, which all contribute to heterogeneity. In addition, a large portion of the reviewed lifestyle interventions did not offer actual exercise training, but exercise/PA recommendations and/or education. This contributes to the large effect size heterogeneity, as previous meta-analyses have shown that actual exercise, not the recommendation, is an important factor impacting the effectiveness of pediatric obesity interventions (Conelly, Duaso, & Butler, 2007). Thus, it is extremely important to provide a quantitative synthesis of the effects of the pediatric lifestyle interventions using rigorous eligibility criteria.

The second gap is that despite being the largest and fastest-growing minority group in the US (Pew Research Center, 2019), Hispanics, in general, and Hispanic adolescents, in particular, have been shown to have fewer opportunities to participate in behavioral interventions

(Haughton et al., 2018; Perez et al., 2013). In addition, underserved populations and particularly Hispanic participants have been shown to have poorer obesity program adherence compared to the general population (Isasi, Rastogi, & Molina, 2016; Moroshko, Brennan, & O'Brien, 2011; Tovar et al., 2014). Thus, tailored obesity prevention strategies are needed to accommodate better the needs of Hispanic adolescents to improve program reach and adherence (Moroshko, Brennan, & O'Brien, 2011).

1.2 Research Questions

Considering the aforementioned evidence in regards to the efficacy of pediatric lifestyle interventions and a need to design psychosocial need-supportive lifestyle intervention programs to treat obesity in Hispanic communities, we designed a Bracing up Research on Adolescents' preVention of Obesity: BRAVO! (BRAVO!) lifestyle intervention program. This program collaborates with local pediatricians to help Hispanic families in their efforts to combat pediatric obesity in their communities. BRAVO! utilizes the latest evidence on positive psychology and psychological need-support strategies (Manninen et al., 2021; Teixeira, Carraça, Markland, Silva, & Ryan, 2012; Ryan & Deci, 2017). This 12-week lifestyle intervention consists of 24 hours of exercise, six hours of nutrition education, and psychological need-support centered behavior modification. A specific description of the BRAVO! intervention is included in Chapter 4.

The overall purpose of this dissertation is to increase understanding about the most effective strategies to improve metabolic health of overweight and obese Hispanic adolescents. Additionally, the purpose is to test the efficacy of the BRAVO! lifestyle program to help

Hispanic communities to battle pediatric obesity. Specifically, this dissertation research had the following aims and hypotheses:

Aim 1:

To summarize and examine the efficacy of randomized controlled pediatric lifestyle interventions (including the combination of exercise, nutrition education, and behavior modification) in treating obesity among 11- to 17-year-old children. The secondary aim was to identify whether age, weight status, intervention type, frequency, or duration moderated the efficacy of the pediatric lifestyle interventions.

1. It is hypothesized that lifestyle interventions including the combination of exercise (actual exercise, not recommendation), nutrition education, and behavior modification are efficacious in treating obesity among 11- to 17-year-old children.
2. It is hypothesized that participant age and weight status as well as intervention type, frequency, and duration moderate the efficacy of the pediatric lifestyle interventions.

Aim 2:

To examine the efficacy of the psychological need-support centered BRAVO! lifestyle intervention on the 12-week and longer-term changes in participants' body composition (BMI, BMIz, and WC) and health-related fitness (cardiovascular endurance and muscular strength/endurance). An additional aim was to explore the changes in participants' PA and psychological outcomes. The hypotheses that underpins this study are as follows:

1. It is hypothesized that BRAVO! will be efficacious in improving participants' BMI, BMIz, and WC.

2. It is hypothesized that BRAVO! will improve participants' cardiovascular endurance and muscle strength/endurance.
3. It is hypothesized that the BRAVO! intervention will increase participants' moderate-to-vigorous intensity PA (MVPA), and improve participants' self-determined motivation and psychological well-being.

1.3 Summary of the Studies

This dissertation will be presented in five chapters. In this chapter the background, problem statement, purpose, and significance of the study are discussed. Chapter II of this dissertation comprehensively reviews the theoretical framework and current literature reviews pertaining to the pediatric lifestyle interventions treating childhood obesity. Chapter III of this dissertation is a systematic review and meta-analysis of lifestyle interventions to prevent and treat pediatric obesity. A priori moderators were examined to determine their influence on the efficacy of pediatric lifestyle interventions during this important stage of human life. Chapter IV of this dissertation is a manuscript presenting the experimental study in testing the efficacy of the psychological need-support centered BRAVO! lifestyle intervention on the 12-week and longer-term changes in participants' body composition (BMI, BMIz, and WC) and health-related fitness (cardiovascular endurance, and muscular strength/endurance). Lastly, Chapter V draws the overall conclusions of this dissertation.

1.4 Public Health Significance

Considering the prevalence of overweight and obesity in underserved communities (Jones-Smith, Dieckmann, Gottlieb, Chow, & Fernald, 2014; Min, Goodale, Xue, Brey, & Wang, 2021; Swinburn et al., 2011), efforts to reduce childhood obesity are well warranted. The current

obesity prevention interventions tend to be less effective in underserved populations. The BRAVO! is expected to treat overweight and obesity by providing an easy access, low-cost lifestyle program treating obesity in Hispanic adolescents. In addition, this study will provide evidence regarding the efficacy of psychological need-supportive lifestyle interventions to be effective in improving motivation, program retention, exercise engagement, and longer-term adherence to health programs in underserved populations. Lastly, the findings of this study may generate new scientific knowledge about effective approaches for obesity treatment with a high potential for replication in underserved areas across the nation.

1.5 Definitions of Key Terms

Overweight is a BMI between the 85th and the 95th age and gender-specific percentile (Cole, Bellizzi, Flegal, & Dietz, 2000)

Obesity is defined as individuals that have a BMI of or above the 95th gender and age-specific percentage (Cole, Bellizzi, Flegal, & Dietz, 2000).

BMI is calculated as weight in kilograms divided by height in meters squared.

Lifestyle Intervention refers to the combination of diet, exercise, and behavior modification which are the most commonly used treatments for youth who are overweight and obese (Styne et al., 2017).

Physical Activity refers to any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen, Powell, & Christenson, 1985).

Physical Fitness consists of the three components of muscle strength, endurance and motor ability, and is a prerequisite for completing daily activities without fatigue and for participating in leisure time activities (Malina & Katzmarzyk, 2006).

Intrinsic Motivation is defined as the process of performing an activity for the sake of itself and refers to activities that are performed due to their inherent satisfaction during active engagement, which is linked to greater productivity, creativity, cognition, flexibility and perseverance (Deci & Ryan, 1985, 2000; Ryan & Deci, 2017).

Integrated regulation involves accepting behaviors as congruent with personal values and interests (Deci & Ryan, 1985, 2000; Ryan & Deci, 2017).

Identified regulation is the process through which people recognize and accept the value of an activity or behavior, and concerns doing something based on the value of its consequences (Deci & Ryan, 1985, 2000; Ryan & Deci, 2017).

Extrinsic regulation refers to individuals performing a behavior to gain a tangible reward or avoid punishment (Deci & Ryan, 1985, 2000; Ryan & Deci, 2017).

Introjected regulation refers to performing behaviors due to internal pressures or compulsion e.g., desire to avoid guilt and shame (Deci & Ryan, 1985, 2000; Ryan & Deci, 2017).

Amotivation refers to a lack of positive attitude and a sense of usefulness that is required to persist in the activity (Deci & Ryan, 1985, 2000; Ryan & Deci, 2017).

1.6 References

1. Berge, J. M., & Everts, J. C. (2011). Family-based interventions targeting childhood obesity: A meta-analysis. *Childhood Obesity*, 7(2), 110-121.
2. Bond, B., Cockcroft, E. J., Williams, C. A., Harris, S., Gates, P. E., Jackman, S. R., ... & Barker, A. R. (2015). Two weeks of high-intensity interval training improves novel but not traditional cardiovascular disease risk factors in adolescents. *American Journal of Physiology-Heart and Circulatory Physiology*, 309(6), H1039-H1047.
3. Brown, H. E., Atkin, A. J., Panter, J., Wong, G., Chinapaw, M. J., & Van Sluijs, E. M. F. (2016). Family-based interventions to increase physical activity in children: A systematic review, meta-analysis and realist synthesis. *Obesity Reviews*, 17(4), 345-360.
4. Cardel, M. I., Atkinson, M. A., Taveras, E. M., Holm, J. C., & Kelly, A. S. (2020). Obesity treatment among adolescents: A review of current evidence and future directions. *JAMA Pediatrics*, 174(6), 609-617.
5. Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports*, 100(2), 126.
6. Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a standard definition for child overweight and obesity worldwide: International survey. *Bmj*, 320(7244), 1240.
7. Connelly, J. B., Duaso, M. J., & Butler, G. (2007). A systematic review of controlled trials of interventions to prevent childhood obesity and overweight: A realistic synthesis of the evidence. *Public Health*, 121(7), 510-517.
8. Craigie, A. M., Matthews, J. N., Rugg-Gunn, A. J., Lake, A. A., Mathers, J. C., & Adamson, A. J. (2009). Raised adolescent body mass index predicts the development of adiposity and a central distribution of body fat in adulthood: A longitudinal study. *Obesity Facts*, 2(3), 150-156.
9. Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum Press.
10. Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227-268.
11. Deng, Y., Manninen, M., Hwang, Y., Kim, T., & Yli-Piipari, S. (in review, 2022). Efficacy of lifestyle interventions to prevent and treat pediatric obesity: A systematic review and meta-analysis.
12. Dietz, W., Lee, J., Wechsler, H., Malepati, S., & Sherry, B. (2007). Health plans' role in preventing overweight in children and adolescents. *Health Affairs*, 26(2), 430-440.
13. Friedemann Smith, C., Heneghan, C., & Ward, A. (2015). Moving focus from weight to health. What are the components used in interventions to improve cardiovascular health in children? *PLoS One*, 10(8), e0135115

14. Goodman, E., & Whitaker, R. C. (2002). A prospective study of the role of depression in the development and persistence of adolescent obesity. *Pediatrics*, 110(3), 497-50
15. Haughton, C. F., Silfee, V. J., Wang, M. L., Lopez-Cepero, A. C., Estabrook, D. P., Frisard, C., ... & Lemon, S. C. (2018). Racial/ethnic representation in lifestyle weight loss intervention studies in the United States: A systematic review. *Preventive Medicine Reports*, 9, 131-137.
16. Ho, M., Garnett, S. P., Baur, L. A., Burrows, T., Stewart, L., Neve, M., & Collins, C. (2013). Impact of dietary and exercise interventions on weight change and metabolic outcomes in obese children and adolescents: A systematic review and meta-analysis of randomized trials. *JAMA Pediatrics*, 167(8), 759-768
17. Ho, M., Garnett, S. P., Baur, L., Burrows, T., Stewart, L., Neve, M., & Collins, C. (2012). Effectiveness of lifestyle interventions in child obesity: Systematic review with meta-analysis. *Pediatrics*, 130(6), e1647-e1671.
18. Isasi, C. R., Rastogi, D., & Molina, K. (2016). Health issues in Hispanic/Latino youth. *Journal of Latina/o Psychology*, 4(2), 67.
19. Jakicic, J. M., Powell, K. E., Campbell, W. W., Dipietro, L., Pate, R. R., Pescatello, L. S., ... & 2018 Physical Activity Guidelines Advisory Committee. (2019). Physical activity and the prevention of weight gain in adults: A systematic review. *Medicine and Science in Sports and Exercise*, 51(6), 1262.
20. Jones-Smith, J. C., Dieckmann, M. G., Gottlieb, L., Chow, J., & Fernald, L. C. (2014). Socioeconomic status and trajectory of overweight from birth to mid-childhood: The early childhood longitudinal study-birth cohort. *PloS One*, 9(6), e100181.
21. Joschtel, B., Gomersall, S. R., Tweedy, S., Petsky, H., Chang, A. B., & Trost, S. G. (2018). Effects of exercise training on physical and psychosocial health in children with chronic respiratory disease: A systematic review and meta-analysis. *BMJ Open Sport & Exercise Medicine*, 4(1), e000409.
22. Kasman, M., Hammond, R. A., Werman, A., Mack-Crane, A., & McKinnon, R. A. (2015). An in-depth look at the lifetime economic cost of obesity. *Brookings Institute*, 12.
23. Kobes, A., Kretschmer, T., Timmerman, G., & Schreuder, P. (2018). Interventions aimed at preventing and reducing overweight/obesity among children and adolescents: A meta-synthesis. *Obesity Reviews*, 19(8), 1065-1079.
24. Lassi, Z. S., Moin, A., Das, J. K., Salam, R. A., & Bhutta, Z. A. (2017). Systematic review on evidence-based adolescent nutrition interventions. *Annals of the New York Academy of Sciences*, 1393(1), 34-50.
25. Lesinski, M., Herz, M., Schmelcher, A., & Granacher, U. (2020). Effects of resistance training on physical fitness in healthy children and adolescents: An umbrella review. *Sports Medicine*, 50(11), 1901-1928.
26. Luckner, H., Moss, J. R., & Gericke, C. A. (2012). Effectiveness of interventions to promote healthy weight in general populations of children and adults: A meta-analysis. *The European Journal of Public Health*, 22(4), 491-497.

27. Maggard, M. A., Shugarman, L. R., Suttorp, M., Maglione, M., Sugerman, H. J., Livingston, E. H., ... & Shekelle, P. G. (2005). Meta-analysis: Surgical treatment of obesity. *Annals of Internal Medicine*, 142(7), 547-559.
28. Malina, R. M., & Katzmarzyk, P. T. (2006). Physical activity and fitness in an international growth standard for preadolescent and adolescent children. *Food and Nutrition Bulletin*, 27(4_suppl5), S295-S313.
29. Manninen, M., Dishman, R., Hwang, Y., Magrum, E., Deng, Y., & Yli-Piipari, S. (2022). Self-determination theory based instructional interventions and motivational regulations in organized physical activity: A systematic review and multivariate meta-analysis. *Psychology of Sport and Exercise*, 102248.
30. Mayr, H. L., Cohen, F., Isenring, E., Soenen, S., & Marshall, S. (2020). Multidisciplinary lifestyle intervention in children and adolescents-results of the project GRIT (Growth, Resilience, Insights, Thrive) pilot study. *BMC Pediatrics*, 20(1), 1-16.
31. Mechanick JI, Youdim A, Jones DB, Garvey T, Hurley DL, McMahon MM...Brethauer S (2013). AACE/TOS/ASMBS Guidelines: Clinical practice for the perioperative nutritional and nonsurgical support of the bariatric surgery patient. – 2013 Update, *Surgery for Obesity and Related Diseases*, 9, 159–191.
32. Min, J., Goodale, H., Xue, H., Brey, R., & Wang, Y. (2021). Racial-ethnic disparities in obesity and biological, behavioral, and sociocultural influences in the United States: A systematic review. *Advances in Nutrition*, 12(4), 1137-1148.
33. Moncada-Jiménez, J., & Carazo-Vargas, P. (2015). A meta-analysis on the effects of exercise training on the VO2max in children and adolescents. *Retos. Nuevas tendencias en Educación Física, Deporte y Recreación*, (27), 184-187.
34. Moroshko, I., Brennan, L., & O'Brien, P. (2011). Predictors of dropout in weight loss interventions: A systematic review of the literature. *Obesity Reviews*, 12(11), 912-934.
35. Ogden, C. L., Carroll, M. D., Fakhouri, T. H., Hales, C. M., Fryar, C. D., Li, X., & Freedman, D. S. (2018). Prevalence of obesity among youths by household income and education level of head of household—United States 2011–2014. *Morbidity and Mortality Weekly Report*, 67(6), 186.
36. Peirson, L., Fitzpatrick-Lewis, D., Morrison, K., Ciliska, D., Kenny, M., Ali, M. U., & Raina, P. (2015). Prevention of overweight and obesity in children and youth: A systematic review and meta-analysis. *Canadian Medical Association Open Access Journal*, 3(1), E23-E33.
37. Perez, L. G., Arredondo, E. M., Elder, J. P., Barquera, S., Nagle, B., & Holub, C. K. (2013). Evidence-based obesity treatment interventions for Latino adults in the US: A systematic review. *American Journal of Preventive Medicine*, 44(5), 550-560.
38. Pew Research Center. 2019 National and state population estimates. Available at <https://www.census.gov/newsroom/press-kits/2019/national-state-estimates.html>. Accessed May 30th, 2021

39. Psaltopoulou, T., Tzanninis, S., Ntanas-Stathopoulos, I., Panotopoulos, G., Kostopoulou, M., Tzanninis, I. G., ... & Sergentanis, T. N. (2019). Prevention and treatment of childhood and adolescent obesity: A systematic review of meta-analyses. *World Journal of Pediatrics*, 15(4), 350-381.
40. Rankin, J., Matthews, L., Cobley, S., Han, A., Sanders, R., Wiltshire, H. D., & Baker, J. S. (2016). Psychological consequences of childhood obesity: Psychiatric comorbidity and prevention. *Adolescent Health, Medicine and Therapeutics*, 7, 125.
41. Ranucci, C., Pippi, R., Buratta, L., Aiello, C., Gianfredi, V., Piana, N., ... & Mazzeschi, C. (2017). Effects of an intensive lifestyle intervention to treat overweight/obese children and adolescents. *BioMed Research International*, 2017.
42. Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Publications.
43. Sahoo, K., Sahoo, B., Choudhury, A. K., Sofi, N. Y., Kumar, R., & Bhadoria, A. S. (2015). Childhood obesity: Causes and consequences. *Journal of Family Medicine and Primary Care*, 4(2), 187.
44. Salam, R. A., Padhani, Z. A., Das, J. K., Shaikh, A. Y., Hoodbhoy, Z., Jeelani, S. M., ... & Bhutta, Z. A. (2020). Effects of lifestyle modification interventions to prevent and manage child and adolescent obesity: A systematic review and meta-analysis. *Nutrients*, 12(8), 2208.
45. Stierman, B., Afful, J., Carroll, M. D., Chen, T. C., Davy, O., Fink, S., ... & Akinbami, L. J. (2021). National health and nutrition examination survey 2017–March 2020 prepandemic data files development of files and prevalence estimates for selected health outcomes.
46. Stoner, L., Rowlands, D., Morrison, A., Credeur, D., Hamlin, M., Gaffney, K., ... & Matheson, A. (2016). Efficacy of exercise intervention for weight loss in overweight and obese adolescents: Meta-analysis and implications. *Sports Medicine*, 46(11), 1737-1751.
47. Styne, D. M., Arslanian, S. A., Connor, E. L., Farooqi, I. S., Murad, M. H., Silverstein, J. H., & Yanovski, J. A. (2017). Pediatric obesity—assessment, treatment, and prevention: An Endocrine Society clinical practice guideline. *The Journal of Clinical Endocrinology & Metabolism*, 102(3), 709-757.
48. Swallen, K. C., Reither, E. N., Haas, S. A., & Meier, A. M. (2005). Overweight, obesity, and health-related quality of life among adolescents: The national longitudinal study of adolescent health. *Pediatrics*, 115(2), 340-347.
49. Swinburn, B. A., Sacks, G., Hall, K. D., McPherson, K., Finegood, D. T., Moodie, M. L., & Gortmaker, S. L. (2011). The global obesity pandemic: Shaped by global drivers and local environments. *The Lancet*, 378(9793), 804-814.
50. Teixeira, P. J., Carraça, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, 9(1), 1-30.
51. Tovar, A., Renzaho, A., Guerrero, A. D., Mena, N., & Ayala, G. X. (2014). A systematic review of obesity prevention intervention studies among immigrant populations in the US. *Current Obesity Reports*, 3(2), 206-222.

52. Yang, S., Qiu, L., Xiao, J., & Luo, C. (2021). The effects of resistance training on children with burns: A meta-analysis. *Pediatric Surgery International*, 37(10), 1323-1332.

CHAPTER II

LITERATURE REVIEW

This dissertation aimed to quantify the effects of randomized controlled pediatric lifestyle interventions in treating childhood obesity. An additional aim of the dissertation was to examine the efficacy of the BRAVO!, the psychological need-support centered lifestyle intervention on overweight and obese participants' body composition and health-related fitness. In this chapter, the factors related to childhood and adolescent obesity are explored, and the role of motivation, specifically the self-determination theory (Deci & Ryan, 1985, 2000; Ryan & Deci, 2017), in developing and maintaining healthy behaviors is discussed. Second, lifestyle intervention studies, including family- and school-based interventions were carefully reviewed to understand their role in treating obesity in youth. By reviewing and critiquing the literature, my purpose is to identify the most effective lifestyle interventions to treat obesity in Hispanic adolescents.

2.1. Etiology of Obesity

Obesity is widely defined as the amount of body fat accumulation that exceeds the biological need of an individual which results in a health risk (Phillips, 2013). Weight gain is the result of an imbalance between energy intake and energy expenditure. When the total energy intake exceeds total energy expenditure in the long term, the consequence is an increase in body mass. Body mass index (BMI), defined as the body mass (kg) divided by the square of the body height (m), is widely used and recommended as a surrogate for body fat (Cole, Bellizzi, Flegal &

Dietz, 2000). There is a consensus that for children and adolescents over 2 years of age, BMI at or greater than the 85th percentile but less than the 95th percentile indicates overweight, and BMI at 95th percentile or more indicates obesity, and BMI $\geq 120\%$ of the 95th percentile or above 35 kg/m² indicates severe obesity (Cole, Bellizzi, Flegal, & Dietz, 2000).

BMI is commonly used in clinical practice because it is straightforward and relatively inexpensive to obtain, but its clinical interpretation is controversial. Discrepancies with the measurement may vary systematically with age (younger and older respondents underestimate their BMI more than respondents aged 42-55 years old), gender, socio-demographic characteristics, and the ethnic/racial background of the respondents (Stommel & Schoenborn, 2009). More direct measures of body fat, e.g., bioelectrical impedance analysis, underwater weighing, and dual-energy x-ray absorptiometry have been shown to be more accurate (Lindsay et al., 2001). However, they are relatively expensive, and rely on more complex technologies which are technically more demanding; thus, they are unfeasible for large populations or routine clinical use. Abdominal obesity is increasingly being recognized as an important cardiovascular risk factor. Abdominal obesity, defined as a WC of ≥ 102 cm in men and ≥ 88 cm in women, is a component of metabolic syndrome and is associated with an increased risk of type 2 diabetes mellitus and hypertension (Klein et al., 2007).

The prevalence of overweight and obesity in children and adolescents has increased worldwide in the past decades (Stierman et al., 2021). The health risks of childhood and adolescent obesity are not only known to be associated with a myriad of morbidities, e.g., cardiovascular diseases, atherosclerosis, hypertension, diabetes, metabolic syndrome (Cardel, Atkinson, Taveras, Holm, & Kelly, 2020), but they are also associated with adverse

psychological effects, e.g., depression, emotional and behavioral disorders, body dissatisfaction, and low self-esteem (Goodman & Whitaker, 2002; Rankin et al., 2016). All of these comorbidities further lead to impaired health-related quality of life and a large economic burden on individuals and nations (Cawley, 2012; Kasman, Hammond, Werman, Mack-Crane, & McKinnon, 2015). In addition, the early development of overweight and obesity in children and adolescents increases the risk of obesity in adulthood (Bond et al., 2015; Craigie et al., 2009; Dietz, Lee, Wechsler, Malepati, & Sherry, 2007).

2.2. Factors Contributing to Obesity in Youth

Although obesity can be largely attributed to an unhealthy energy-dense diet, insufficient PA, and genetic predisposition, there are numerous factors e.g., family meals, media use, and sleep that relate to obesity. Previous research has found e.g., genetic, metabolic, behavioral, environmental, and cultural/societal to influence individuals' eating and exercise/PA patterns (Hruby & Hu, 2015; Jackson, Llewellyn, & Smith, 2020). Although various theories have been used to understand and explain obesity, this study applied the Socioecological model recognizing the different layers of influence, i.e., individual influences (intra-individual), parenting and family factors (inter-individual), and community and societal factors (Sallis, Owen, & Fisher, 2015).

2.2.1 Genetic Factors

Epigenetics and genetics play a role in the precipitous rise in obesity (Maes, Neale, & Eaves, 1997). Children whose parents are obese have a higher risk of being obese when compared to the children of non-obese parents (Lake, Power, & Cole, 1997). Specifically, it is reported that there is a 30% chance of obesity if one parent is obese, and a 90% chance if both parents are obese

(Cuda & Censani, 2019). There are a number of more extreme parental behaviors, e.g., alcohol abuse and insufficient maternal weight gain for infants at gestational age, that have been shown to increase the risk of obesity. In addition, toxins, nutrition, antibiotics, and exogenous hormones can also result in obesogenic epigenetic changes (Principi & Esposito, 2016). However, genetics rarely have by itself the power to determine an individual's physiology or behavior. It is the modified interaction between genes and environment that can influence and activate weight gain (Chang & Neu, 2015).

2.2.2 Behavioral and Environmental Factors

2.2.2.1 Nutrition

Children and adolescents' eating behaviors are influenced by the accessibility and availability of foods. Compared to decades ago, people were exposed to more high fat/caloric, palatable, and inexpensive foods than ever. Industrialized technologies have enabled the production of cheap and calorie-dense but nutrient-poor foods in abundance for people's daily consumption. This has been a major factor in the escalating prevalence of obesity to a global epidemic concern (Wyatt, Winters, & Dubbert, 2006). Researchers have found that the US population, in general, is consuming a diet that is low in micronutrients and fiber and high on the glycemic index, with extreme (super-sized) portion sizes leading to excessive calorie consumption beyond the daily recommendations (Rosenheck, 2008). In addition, consuming sugar-sweetened beverage has been postulated as an important contributor to the development of obesity in children (Malik, Pan, Willett, & Hu, 2013). It is reported that the average sugar-sweetened beverage consumption in the US is 270 kcal/day, representing 10% to 15% of the total caloric intake (Kuczmarski, 2000). It is reported that, on average, children and adolescents currently 30% to 40% of their

calories from nutrient-poor, energy-dense food and drinks (Council on School Health, and Committee on Nutrition, 2015). The pediatric obesity guidelines (Styne et al., 2017) advocate for the consumption of a variety of fruits, vegetables, whole grains, dairy products, fish, legumes, poultry, and lean meat. Limiting foods high in saturated fats (less than 10% of calories per day), cholesterol (less than 300 mg/day), trans-fatty acids, and salt intake to less than five grams per day are also recommended. However, adherence and maintenance to the recommendations are reportedly low (Banfield, Liu, Davis, Chang, & Frazier-Wood, 2016).

2.2.2.2 Physical Activity and Exercise

Increasing regular PA and decreasing sedentary time are widely accepted as strategies to help treat obesity. Current PA guidelines for children and adolescents ages six through 17 recommend at least 60min of MVPA each day and activities that strengthen the musculoskeletal system at least three times a week (World Health Organization, 2020). Multiple physical and mental benefits can be attained through regular PA. For example, improvements in cardiovascular fitness are associated with improvements in body composition and diabetes risk factors in adolescents (Lee et al., 2014). In addition, improvements in metabolic fitness are linked to improvements in cognitive function and concentration (Davis et al., 2011). Accumulating evidence emphasizes that regular PA, especially MVPA, and decreasing sedentary time play an important role in treating overweight and obesity. For example, systematic reviews have confirmed that interventions aimed to improve MVPA have a simultaneous effect on empowering other health-related behaviors, e.g., healthy eating or weight management (Janssen & LeBlanc, 2010).

Despite these benefits, data have shown that 80% of children and adolescents do not achieve the recommended levels of PA, and children and adolescents with obesity are less physically active compared with children with a healthy weight (Thivel et al., 2018). Multiple factors can influence the promotion of PA. Firstly, environmental factors have made PA behaviors more difficult, especially in urban environments. Urban sprawl has created suburban settings that do not promote walking; instead necessitating the use of a car for most tasks. Consequently, changes in our physical environment have discouraged children from playing outside. Secondly, PA for school-aged children may be hampered by decreased physical education time and recess time and expectations placed upon teachers to improve academic teaching (Anderson & Butcher, 2006). Last but not the least, unsafe neighborhood environments and the cost of participating in, or equipment for, sporting activities are factors contributing to the lack of regular PA (McWhorter, Wallmann, & Alpert, 2003).

Research has found a positive association between sedentary time and the risk for obesity (Tandon et al., 2012; Tremblay et al., 2011). Twenty years ago, it was reported that, on average, an American child spends 25 hours weekly in the front of the television (Proctor et al., 2003). Nowadays, hours spent on digital /social media, including computers, tablets, and smartphones are even higher compared to the screen time 20 years ago (Kabali et al., 2015). Adolescents now spend the majority of their non-TV screen time on smartphones, and much of that time is spent on social media platforms (e.g., Instagram, YouTube, Facebook). The amount of time spent watching television, the presence of a television in a child's and adolescent's room, and using digital media have all been shown to be directly related to the prevalence of obesity in children and adolescents (Gilbert-Diamond et al., 2014). This association can be explained by several

potential mechanisms including the displacement of PA, and adverse effects on the quality and quantity of food consumed (Lipsky & Iannotti, 2012). In addition, researchers have found that the use of electronic games has been associated with obesity (Stettler, Signer, & Suter, 2004). It is recommended that obese children and adolescents limit nonacademic screen time to 1-2 hours per day and decrease other sedentary behaviors, e.g., digital activities (Styne et al., 2017).

2.2.2.3 Cultural/Societal Factors

Family, cultural, and societal factors are impacting how people are moving and eating. The development of eating behavior is largely affected by factors e.g., availability of and preference for particular foods, portion sizes, parents' beliefs and practices, and feeding styles (Story, Neumark-Sztainer, & French, 2002). Indeed, children's food-related knowledge, preferences, and consumption are highly related to parents' preferences, beliefs, and attitudes toward food. Research has shown that parental influences are early determinants of food attitudes, and practices in young children's food preferences, which may later associate with children's weight (Birch & Davison, 2001). Parents are also an important influence on their children's PA and sports participation through role modeling (being active themselves), material support (financial, logistic, co-participation), and encouragement (Gustafson & Rhodes, 2006). The past systematic review by Boreham and Riddoch (2001) has shown that physically active parents are more likely to have physically active children. In summary, parents' behaviors with regard to dietary characteristics, food preferences, intake regulation (e.g., dietary inhibition), and PA are related to the subsequent behaviors of their children. Interventions aimed at improving children's nutrition and PA are needed to address the variety of social and physical factors that influence children's eating patterns and sedentary behaviors (Patrick & Nicklas, 2005).

2.3. The Role of Motivation in Healthy Weight and Lifestyle

Motivation toward health behaviors, e.g., dietary and PA behaviors, is an important element relating to individuals' healthy weight management and obesity. Motivation relates to not only healthy behaviors, but also to participant engagement in and adherence to, for instance, obesity prevention and treatment interventions (Sheldon, Willams, & Joiner, 2003). Promoting effective health behaviors and maximizing program success requires serious consideration of the motivational basis for the change.

Numerous motivational theories have been suggested to address this dilemma. One of the most prominent theories to understand human behaviors and well-being is the self-determination theory (SDT; Deci & Ryan, 1985, 2000; Ryan & Deci, 2017). SDT not only offers a broader perspective on human functioning but also provides a framework to understand the myriad behaviors in terms of basic psychological needs and motivation regulations.

SDT postulates that human beings are inherently proactive; they actively act on both internal and external forces they encounter rather than are passively controlled by those forces, and steadily move towards increasing levels of psychological growth and integration (Deci & Ryan, 1985). The satisfaction and thwarting of these psychological needs play a critical role in the process of growth and integration. Three psychological needs are identified by SDT: competence, relatedness, and autonomy (Deci & Ryan, 1985). Competence is considered one of three fundamental psychological needs that can energize human activity and refers to the need to feel capable of achieving desired outcomes/goals. Relatedness is the desire to feel connected to others e.g., peers, family, and community. Autonomous behavior refers to a sense of free

choices, accompanied by an internal perceived locus of causality and true volition, while minimizing pressure and control. Accordingly, autonomous behaviors are more likely to result in meaningful, long-lasting changes in behaviors (Deci & Ryan, 2000). Research argues that satisfying these needs is critical for psychological thriving and well-being (Deci & Ryan, 2000).

Motivation varies based on individuals' perception of the locus of control ranging from controlled (regulated by external forces) to autonomous (self-determined) regulation. External regulation, at the lower end of the continuum, is the most controlling form of motivation and refers to individuals performing a behavior to gain a tangible reward or avoid punishment. Introjected regulation refers to performing behaviors due to internal pressures or compulsion e.g., the desire to avoid guilt and shame. Identified regulation concerns doing something based on the value of its consequences. Integrated regulation involves accepting behaviors as congruent with personal values and interests. Intrinsic motivation refers to activities that are performed due to inherent satisfaction with active engagement, which is linked to greater productivity, creativity, cognition, flexibility, and perseverance. Finally, amotivation refers to a lack of positive attitude and a sense of usefulness that is required to persist in the activity (Deci & Ryan, 2000).

SDT further postulates that psychological needs support or facilitate adaptive personal and social functioning (Ryan & Deci, 2017). For example, when adolescents' environments comprise these need-supportive components (i.e., a psychological environment that supports the previously mentioned basic needs), motivation guiding their engagement in healthy lifestyle behaviors is more likely to be self-determined and the behavior engaged in. More autonomous and intrinsic motivation has been shown to be powerful predictors of successful self-regulation

in domains of exercise (Fortier, Sweet, O'Sullivan, & Williams, 2007; Teixeira et al. 2012), eating (Pelletier & Dion, 2007), and weight loss and maintenance (Teixeira et al., 2006).

Previous research has shown that when physicians are perceived by their patients as being autonomy supportive, patients report greater self-motivation for treatment adherence (Williams et al., 2004). Conversely, behavior controlled by rewards or punishments is predicted to last as long as the contingencies remain in place.

2.4. Lifestyle Interventions

Lifestyle intervention programs can be effective in weight reduction with long-term weight loss maintenance possible and cardiometabolic health improvement (Lloyd-Richardson et al., 2012).

Lifestyle interventions consisting of exercise and nutrition education are regarded as a non-invasive strategy to prevent/treat childhood obesity. The primary goal of lifestyle interventions is to improve dietary behaviors (e.g., increase fruits and vegetable intake, reduce the consumption of sugary drinks and trans-fats, and improve healthy energy balance), increase regular PA and improve fitness levels, and eventually promote health both body composition and reduce cardiometabolic risk factors (Pandita et al., 2016). Since there are few adverse effects associated with this lifestyle intervention approach, it is recommended as an integral and preferred part of obesity treatment across different treatment modalities (LeBlanc et al., 2018).

2.4.1 Dietary Intervention Component

Dietary modification targets the quantity and quality of energy intake while improving the nutritional quality of foods consumed. The most commonly used family-friendly approach, Traffic Light Diet, has been found to significantly decrease adolescent BMI decrease of .18-2.6 kg/m² in interventions ranging from six months to two years (Ho et al., 2012). Other

interventions have focused on altering the macronutrient distribution of the diet, including low-fat diets, low-carbohydrate/high-protein diets, low glycemic-index diets, balanced-deficit diets, vegetarian, vegan, various diets based on dietary patterns, and diets eliminating one or more major food groups. Each diet has associated with significant weight loss and a reduction in the predicted risk of atherosclerotic cardiovascular disease events from eight weeks to 24 months in duration (Sackner-Bernstein Kanter, & Kaul, 2015).

2.4.2 Exercise and Physical Activity Intervention Component

Modifying energy expenditure is focused on decreasing sedentary behavior and increasing MVPA. Research has found that MVPA-based exercise intensities have been shown to positively affect body composition by reducing body fat and positively impacting body composition (Schranz, Tomkinson, & Olds, 2013). Several meta-analyses have summarized the effectiveness of lifestyle interventions on children's PA behaviors (Brown et al., 2016; Metcalf, Henley, & Wilkin, 2012). These syntheses have demonstrated small sized effects on total PA (Standard Mean Differences (SMD); SMD = .12, 95% CI [.04, .20], $p = .010$); Metcalf, Henley, & Wilkin, 2012) and MVPA (SMD = .29, 95% CI [.14, .45], $p < .001$; Brown et al., 2016).

Researchers have further found that body fat percentage tends to reduce to a greater extent when PA is combined with resistance exercise (1.20, 95% CI [.34 –2.10]) compared to situations when aerobic activity is implemented alone (.58, 95% CI [.18 –.90]) (LeMura & Maziekas, 2002). Other research has found exercise to be predictive of sustained weight change 10 years after engagement in a weight loss intervention in adolescents (Epstein, Valoski, Wing, & McCurley, 1994). However, PA alone often does not have a notable effect on BMI in pediatric populations.

2.4.3 Behavior Modification Component

Behavioral strategies are often based on cognitive behavioral therapy, assisting participants in modifying their dietary, PA, and sleep behaviors through skill development in self-monitoring, goal-setting, identifying barriers to change, problem-solving, and stimulus control (Wadden & Foster, 2000). The purpose of these interventions is to help participants manage negative emotional states and encourage changing negative thoughts (e.g., certain food cravings) through cognitive reframing and distraction techniques to maintain their weight change. There is usually a participant manual and a coaching manual that outlines the skills that are being taught for each session. Long-term weight loss maintenance requires sustained behavior change (Thomas, Bond, Phelan, Hill, & Wing, 2014). A minimum of 12 sessions over the first year is recommended (LeBlanc et al., 2018).

2.5. Efficacy of Lifestyle Interventions

The increased prevalence of adolescent obesity and associated short-term and long-term complications emphasize the need for effective treatments (Nemet et al., 2015). Several meta-analytic reviews have reported that lifestyle interventions can be efficacious in improving participants' weight status and reducing weight-related risk factors in the short term (Brown et al., 2016; Berge & Everts, 2011; Ho et al., 2012). It has been found that additional benefits of lifestyle interventions in obese populations are reductions in urinary incontinence, sleep apnea, depression, improvements in quality of life, and physical function, and a delay in the development of type 2 diabetes (Look AHEAD Research Group, 2013). The clinical guideline from the American Heart Association found with a combination of lifestyle intervention treatment results in a weight loss of 5% to 8 % of initial body weight. Recommended lifestyle

interventions that include the combination of diet, PA, and behavior therapy are efficacious for reducing body weight and treating obesity (Jensen et al., 2014).

Researchers have found that the combination of decreased caloric intake and exercise can achieve and maintain significant weight loss (Styne et al., 2017). A systematic review of a meta-analysis conducted by Psaltopoulou et al. (2019) examined the effectiveness of treatments on childhood and adolescent obesity. This study reviewed 66 meta-analysis studies that collectively included 900,000 participants. They found that combined interventions including PA and nutritional modifications seemed to represent the most effective modality to tackle childhood obesity regarding both prevention and treatment. They proposed that the combination of enhanced PA and improved nutrition emerged as a promising intervention that can be beneficial to prevent obesity in childhood and adolescence. In addition, Patsopulou et al. (2017), examining 13- to 15-year-old obese adolescents, found a 12-week long “Diet & Activity” intervention to be effective in reducing participants’ BMI (-1.4 kg/m^2 , 95% CI $[-1.3, -1.2]$), and the reductions in BMI (-3.1 kg/m^2 , 95% CI $[-3.3, -2.8]$) were even greater at 24 weeks. Moreover, Ho et al. (2013) examined 15 studies on the effect of diet-only, exercise-only, and diet with exercise intervention on weight loss and metabolic risk reduction in overweight children in short-term trials. Both diet-only and diet with exercise interventions resulted in weight loss and metabolic profile improvement. They found that the combination of exercise and diet intervention led to greater improvements in levels of high-density lipoprotein cholesterol (3.86 mg/dL , 95% CI $[2.70, 4.63]$), fasting glucose (-2.16 mg/dL , 95% CI $[-3.78, -.72]$), and fasting insulin ($-2.75 \text{ } \mu\text{IU/mL}$, 95% CI $[-4.50, -1.00]$) over six months. However, lacking rigorous designs, behavior

modification strategies, and a longer duration of follow-up, long-term sustainability effects were not well-understand.

Several meta-analyses have reported that lifestyle interventions can be efficacious in improving children and adolescents' weight status, BMI, WC, and reducing numerous weight-related risk factors, e.g., low-density lipoprotein and fasting insulin (Berge & Everts, 2011; Deng et al., in review; Ho et al., 2012; Luckner, Moss, & Gericke, 2012; Peirson et al., 2015; Salam et al., 2020; Stoner et al., 2016). When focusing on BMI as a primary indicator, the published meta-analyses have shown pediatric lifestyle interventions to be efficacious, with the effect sizes ranging from between (-.09 kg/m², 95% CI [.16, -.03]); Luckner, Moss, & Gericke, 2012) to (-2.00 kg/m², 95% CI [-1.5, -2.5]); Stoner et al., 2016).

However, research has shown inconsistency in the efficacy of lifestyle interventions in improving children and adolescents' weight status, BMI, and WC. For example, Kamath et al. (2008) examined the impact of the lifestyle intervention on both lifestyle behaviors and BMI, and they found a reduction in unhealthy dietary habits ($p = .020$), and increased PA ($p = .060$), but they didn't find significant changes in BMI. In addition, one of the most recent meta-analyses by Hamid and Sazlina (2019) ($k = 14$, age range 9-12 years) from the years 2000 to 2017 found that lifestyle interventions did not have a statistically significant effect on BMIz, WC, or body fat. The authors emphasized the importance of the role of interdisciplinary team approaches with family involvement using behavior and lifestyle strategies to curb obesity among school children (6-12 years). In summary, the efficacy of lifestyle interventions on children and adolescents' weight status and BMI has been inconsistently observed with a large

degree of heterogeneity across studies. Factors e.g., intervention length, frequency, and content, all contribute to heterogeneity.

It is well-known that there is an inverse relationship between BMI and physical fitness (Jackicic et al., 2019). Recent evidence suggests that childhood interventions should have a broader focus and target not only weight but improving children's cardiovascular and muscle health (Friedemann, Heneghan, & Ward, 2015; Mayr, Cohen, Isenring, Soenen, & Marshall, 2020). Several meta-analytic reviews have been published to summarize the effectiveness of exercise training on children's cardiovascular and muscular health (Joschtel et al., 2018; Lesinski, Herz, Schmelcher, & Granacher, 2020; Moncada-Jiménez & Carazo-Vargas, 2015; Yang, Qiu, & Luo, 2021). For instance, Joschtel et al. (2018; $k = 24$) showed exercise training yielding large significant effects on cardiovascular fitness (oxygen consumption, VO_2 max) (SMD = 1.16, 95% CI [.61, 1.70]). Yang, Qiu, and Luo (2021; $k = 12$) showed that resistance training can improve participants' VO_2 max (SMD = 5.83, 95% CI [3.52, 8.13], $p < .001$) and muscle strength (SMD = 2.18, 95% CI [.79, 3.56], $p = .002$), but not muscle endurance (SMD = 10.00, 95% CI [-.22, 20.22], $p = .060$). These findings (Yang, Qiu, & Luo, 2021) corroborated the findings of Lesinski, Herz, Schmelcher, & Granacher (2020; $k = 11$), which have shown resistance training to result in medium-to-large effects on muscle strength ($.54 \leq \text{SMD} \leq 1.12$) and small-to-large effects on muscle power ($.41 \leq \text{SMD} \leq .80$).

2.5.1 Family-Based Lifestyle Interventions

The central tenet of family-centered interventions is the reckoning that families play an important role in influencing children's behaviors. The uniqueness of the family system is to provide a greater change and longer sustainability of change in the children because of the ability

of the family to shape children's behaviors on a daily basis. Evidence suggests that the adherence to the entire family to an intervention program represents an important predictor of the intervention's success (Gilles et al., 2008). Family-centered interventions have been shown to be effective in improving participants' body composition (Balagopal et al., 2005; Kalavainen, Korppi & Nuutinen, 2007; Kalarchian et al., 2009), insulin sensitivity, and lipids panels (Balagopal et al., 2005), and body weight maintenance (Golan & Crow, 2004).

Several meta-analyses have shown family-based interventions to be associated with the modest but clinically important short-term reduction in children's body composition (Oude Luttikhuis et al., 2009; Wilfely et al., 2007). In a study by Kalavainen et al. (2007), obese children aged 7-9 years were randomly allocated either to routine counseling (two appointments for children) or family-based group treatments. Family-based group treatments consisted of 15 group sessions including nutrition education, PA education, and behavioral therapy. This study included a 6-month intervention and a 6-month follow-up. The findings supported the efficacy of the family-based group interventions on positive changes in BMI (.8 vs .00, $p = .003$) compare to the control group. Even though beneficial effects were partly lost, there was a significant difference fin BMIz compared to the control group ($p = .008$) after the six months of the intervention. This study suggests that long-term follow-up studies are needed to further evaluate the effect of family-based interventions (Kalavainen et al., 2007).

Similar to the previous study, Kalarchian et al. (2009) studied the efficacy of a family-based, behavioral weight control intervention in treating severe pediatric obesity. The study consisted of 192 children 8- to 12-year-old ($M = 10.2 \pm 1.2$). Assessments were conducted at the baseline, six months, 12 months, and 18 months. The intervention group included behavioral

strategies, PA education, and diet, and the control group only included a nutrition plan. When compared to the control group, the intervention group showed a 7.58% decrease in children's overweight percent in the short term (at six months), compared with a .66% decrease in the control group, but differences were not significant at 12 or 18 months. Children whose attendance rate was greater than 75% were able to reduce their overweight percentage across 18 months. The authors of the study concluded that the attendance percentage greater than 75% contributed to longer-term weight loss.

Another study conducted by Ranucci et al. (2017) examined the effects of a family-based lifestyle intervention to treat overweight/obese children and adolescents. A sample of 74 participants was allocated to the children's group ($n = 43$, age 5-12 years) and adolescents' group ($n = 31$, age 13-17 years). The intervention included exercise, nutrition, and psychological strategies, and it was delivered for six months for the children and three months for the adolescents. Overall, the authors found that both children and adolescents showed a significant reduction in body weight and WC in short-term fitness performance.

2.5.2. School-Based Interventions

Schools are regarded as a promising setting to implement interventions for youth, given that children and adolescents spend a large amount of time at school. This setting has been recommended as preferential for implementing large-scale interventions in preventing obesity and promoting health (Budd & Volpe, 2006; Katz, 2009). Normally, school-based lifestyle interventions involve both a family and school, and typically the programs integrate PA, behavioral counseling, parent modeling, and healthy eating habits.

Numerous school-based interventions have focused on reducing childhood obesity (Connelly, Duaso, & Butler, 2007; Oosterhoff, Joore & Ferreira, 2016). Research has shown inconsistent results in the efficacious of the school-based obesity interventions (Connelly, Duaso, & Butler, 2007; Cook-Cottone, Casey, Feeley, & Baran, 2009; Gonzalez-Suarez, Worley, Grimmer-Somers, & Dones, 2009; McMurray et al., 2002). For instance, findings of the meta-analytical analyses have shown inconsistent results in BMI (Connelly, Duaso, & Butler, 2007; Gonzalez-Suarez, Worley, Grimmer-Somers, & Dones, 2009), eating and PA (Cook-Cottone, Casey, Feeley, & Baran, 2009; Gonzalez-Suarez, Worley, Grimmer-Somers, & Dones, 2009), in reducing body fat and lowering blood pressure and cholesterol (Mcmurray et al., 2002). For instance, Llargues et al. (2011) evaluated the efficacy of the two-year intervention on food habits and PA of school children between ages five and six. The intervention consisted of the promotion of healthy eating habits and PA. Results found that BMI in the control group ($.89 \text{ kg/m}^2$) was higher than in the intervention schools. The intervention reduced the prevalence of overweight in children by 62%. This study suggested that education in healthy eating habits and PA in the school could contribute to lessening the current increase in child obesity.

Aperman-Itzhak et al. (2018) evaluated the effectiveness of a healthy lifestyle intervention on health knowledge, behavior, and anthropometric measurements. A sample of 396 grade five and six students were assessed on their eating habits and PA. The intervention group focused on eating education (e.g., eating healthy breakfast, drinking water, and reading food labels) and PA knowledge. Knowledge was improved in both study groups ($p < .010$), with no difference in health behavior scores at the beginning ($p = .590$) or at the end ($p = .360$; after a year). Overweight and obesity decreased significantly within the intervention group (from 25%

to 17.9%, $p = .040$) compared to the control group (from 20.5% to 17.6%, $p = .120$). The result indicated that school-based healthy lifestyle educational programs can elicit some positive changes in children.

Sgambato et al. (2019), on the other hand, assessed the effectiveness of a combined school- and home-based obesity prevention program in preventing excessive weight gain in adolescents. This study targeted fifth and sixth graders' healthy eating habits and PA. A subgroup of overweight or obese adolescents received a home-based secondary prevention program delivered by community health professionals. Results found that the intervention group participants increased PA by 12.5 minutes per week and ate healthier than the control group participants, but there was no significant effect on BMI. Female adolescents in the intervention group ate healthier more frequently than the control group females. Researchers summarized that low adherence to the protocol e.g., only 20% of overweight students visited the community health agents, may have contributed effectiveness of the program. Finally, one of the most recent meta-analyses conducted by Hamid and Sazlina (2019) examining school children did not find school-based obesity interventions to produce any statistically significant intervention effects on participants' weight-related outcomes.

2.5.3 Self-Determination Centered Interventions

Motivation plays a major part in the success of treatments and interventions that aim to improve individuals' health and well-being. Recent research advances centered around the SDT have shown that program adherence and long-term weight loss can be improved by designing programs harnessing participants' psychological needs (Deci & Ryan, 2000; Williams, Grow, Freedman, Ryan, & Deci, 1996). Specifically, research indicates that if individuals' innate,

psychological needs of autonomy (i.e., to experience growth and self-control), competence (i.e., to feel accomplished), and relatedness (i.e., to feel accepted by others and connected to the social environment) are met, it can lead to improved self-determined motivation, long-term goal adoption, and more successful goal-pursuit. Research has found that intrinsic motivation is related to long-term exercise adherence and higher intensity PA (Teixeira, Carraça, Markland, Silva, & Ryan, 2012). Programs that incorporate these psychological need-supportive strategies have shown to be more effective due to better program adoption, engagement, and retention (Williams, McGregor, Zeldman, Freedman, & Deci, 2004).

According to the basic tenets of SDT, successful maintenance of weight reduction would occur when people choose eating and exercise behaviors because they personally value weight loss maintenance and its health benefits. In other words, successful weight loss and long-term maintenance would not be achieved, if the reasons for it were mostly controlling (e.g., parents' recommendations). Research has supported this argument showing that during a weight control program, the degree of autonomous motivation predicted not only attendance and weight loss, but the maintenance of weight loss at the 23-month follow-up (Williams, Grow, Freedman, Ryan, & Deci, 1996).

Studies on dieting from the SDT perspective have indicated an association between autonomous reasons for dieting and more successful outcomes (Vansteenkiste, Simons, Braet, Bachman, & Deci, 2005). Katz, Madjar, and Harari (2015) examine the parent's role in overweight adolescents' motivation to diet and weight loss. This study examined 99 participants aged 20- to 30-year-old who had been overweight during adolescence. They found that participants who viewed their parents as more need-supportive demonstrated more autonomous

motivation to diet, and successful weight loss. This finding highlights the importance of parental support to adolescents' psychological needs in the quality of their motivation to diet.

Yli-Piipari et al. (2018) conducted a study to assess the impact of a 12-week, twice a week lifestyle intervention comprising of dietary education, exercise, and self-determination theory centered behavior modification on overweight Hispanic adolescents and children. The researchers found that the intervention facilitated a significant reduction in WC ($p = .020$) and BMI ($p = .023$) and positive changes in glucose levels ($p < .001$), MVPA ($p = .002$), intrinsic motivation ($p = .002$), and introjected regulation ($p = .014$). Researchers suggested that a 12-week lifestyle program can be effective in the risks of type 2 diabetes and cardiovascular diseases. In addition, the authors concluded that it is necessary to determine the long-term effects SDT centered interventions by using randomized controlled study designs.

2.6. The Present Dissertation Research

In this section, based on the knowns and gaps, I present the purpose and the specific aims of the current dissertation research.

2.6.1 What We Know

The literature review above demonstrates that multi-component behavioral lifestyle interventions can produce significant and clinically meaningful reductions in overweight and obesity in children and adolescents compared to standard care. In addition, it has been shown that a multi-component lifestyle intervention combining exercise, nutrition education, and behavior modification can produce a stronger effect compared to a single-component intervention study (Osei-Assibey et al., 2012). The literature suggests that multi-component interventions have small to moderate effects on obesity in children and adolescents. It further indicates that various

modalities, especially the combination of aerobic and resistance exercise, have been shown to positively impact body composition by reducing BMI. Thirdly, it is recommended that minimum of 12-weeks intervention is needed to produce a positive effect on weight-related outcomes, but researchers recommend including a long-term follow-up to examine the maintenance of the behavior change.

It is also shown that STD-based behavior modification strategies can have a positive influence on improving engagement in and adherence to health behavior programs. Similarly, SDT centered need-support has been shown to have a positive effect on improving participants' self-determined motivation and PA after the program. The degree of self-determined motivation has consistently been shown to have positive effects on weight loss and maintenance of weight loss (Williams, Grow, Freedman, Ryan, & Deci, 1996). In addition, intrinsic motivation and identified regulation toward exercise have been shown to be the strongest predictors of long-term behavior change (Teixeira et al., 2006).

2.6.2 What We Do Not Know

First, although the previous literature review demonstrates that lifestyle interventions (i.e., programs comprising of exercise, nutrition education, and behavior modification) are effective, non-invasive treatment for childhood obesity, there are very few non-clinical, easy access opportunities to participate in a lifestyle intervention treatment among youth. Access has been especially scarce in underserved populations, e.g., high-risk Hispanic population. Thus, it is highly important to provide these opportunities to Hispanic youth.

Second, it has been shown that SDT-based interventions can positively influence overweight and obesity as well as PA among children and adolescents (Ismaeel et al., 2017; Yli-

Piipari et al., 2018). However, few studies have examined whether SDT-centered lifestyle interventions have longer-term effects on participants' body composition or health-related fitness. Understanding the role of psychosocial factors (self-determined motivation) in reducing obesity risk factors can provide new insight and knowledge about effective intervention programs in the longer term.

Finally, most empirical studies have found that the intervention program is limited by age, weight status, intervention type, frequency, or duration moderated the efficacy of the pediatric lifestyle interventions variables can help us understand the effects of program feasibility and efficacy on adherence.

2.6.3 The Purpose of the Dissertation Research

This dissertation aimed to quantify the effects of randomized controlled pediatric lifestyle interventions in preventing and treating childhood obesity. An additional aim of the dissertation was to examine the efficacy of the BRAVO!, the psychological need-support centered lifestyle intervention, on overweight and obese participants' body composition and health-related fitness.

2.7 References

1. A. Hamid, M. S., & Sazlina, S. G. (2019). Interventions for obesity among schoolchildren: A systematic review and meta-analyses. *PloS One*, 14(1), e0209746.
2. Anderson, P. M., & Butcher, K. F. (2006). Childhood obesity: Trends and potential causes. *The Future of Children*, 19-45.
3. Aperman-Itzhak, T., Yom-Tov, A., Vered, Z., Waysberg, R., Livne, I., & Eilat-Adar, S. (2018). School-based intervention to promote a healthy lifestyle and obesity prevention among fifth-and sixth-grade children. *American Journal of Health Education*, 49(5), 289-295.
4. Balagopal, P., George, D., Patton, N., Yarandi, H., Roberts, W. L., Bayne, E., & Gidding, S. (2005). Lifestyle-only intervention attenuates the inflammatory state associated with obesity: A randomized controlled study in adolescents. *The Journal of Pediatrics*, 146(3), 342-348.
5. Banfield, E. C., Liu, Y., Davis, J. S., Chang, S., & Frazier-Wood, A. C. (2016). Poor adherence to US dietary guidelines for children and adolescents in the national health and nutrition examination survey population. *Journal of the Academy of Nutrition and Dietetics*, 116(1), 21-27.
6. Berge, J. M., & Everts, J. C. (2011). Family-based interventions targeting childhood obesity: A meta-analysis. *Childhood Obesity*, 7(2), 110-121.
7. Birch, L. L., & Davison, K. K. (2001). Family environmental factors influencing the developing behavioral controls of food intake and childhood overweight. *Pediatric Clinics*, 48(4), 893-907.
8. Bond, B., Cockcroft, E. J., Williams, C. A., Harris, S., Gates, P. E., Jackman, S. R., ... & Barker, A. R. (2015). Two weeks of high-intensity interval training improves novel but not traditional cardiovascular disease risk factors in adolescents. *American Journal of Physiology-Heart and Circulatory Physiology*, 309(6), H1039-H1047.
9. Boreham, C., & Riddoch, C. (2001). The physical activity, fitness and health of children. *Journal of Sports Sciences*, 19(12), 915-929.
10. Brown, H. E., Atkin, A. J., Panter, J., Wong, G., Chinapaw, M. J., & Van Sluijs, E. M. F. (2016). Family-based interventions to increase physical activity in children: A systematic review, meta-analysis and realist synthesis. *Obesity Reviews*, 17(4), 345-360.
11. Budd, G. M., & Volpe, S. L. (2006). School-based obesity prevention: Research, challenges, and recommendations. *Journal of School Health*, 76(10), 485-495.
12. Cardel, M. I., Atkinson, M. A., Taveras, E. M., Holm, J. C., & Kelly, A. S. (2020). Obesity treatment among adolescents: A review of current evidence and future directions. *JAMA Pediatrics*. 174(6), 609-617.
13. Cawley, J., & Meyerhoefer, C. (2012). The medical care costs of obesity: An instrumental variables approach. *Journal of Health Economics*, 31(1), 219-230.

14. Chang, L., & Neu, J. (2015). Early factors leading to later obesity: Interactions of the microbiome, epigenome, and nutrition. *Current Problems in Pediatric and Adolescent Health Care*, 45(5), 134-142
15. Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a standard definition for child overweight and obesity worldwide: International survey. *Bmj*, 320(7244), 1240.
16. Connelly, J. B., Duaso, M. J., & Butler, G. (2007). A systematic review of controlled trials of interventions to prevent childhood obesity and overweight: A realistic synthesis of the evidence. *Public Health*, 121(7), 510-517.
17. Cook-Cottone, C., Casey, C. M., Feeley, T. H., & Baran, J. (2009). A meta-analytic review of obesity prevention in the schools: 1997–2008. *Psychology in the Schools*, 46(8), 695-719.
18. Council on School Health, & Committee on Nutrition. (2015). Snacks, sweetened beverages, added sugars, and schools. *Pediatrics*, 135(3), 575-583.
19. Craigie, A. M., Matthews, J. N., Rugg-Gunn, A. J., Lake, A. A., Mathers, J. C., & Adamson, A. J. (2009). Raised adolescent body mass index predicts the development of adiposity and a central distribution of body fat in adulthood: A longitudinal study. *Obesity Facts*, 2(3), 150-156.
20. Cuda, S. E., & Censani, M. (2019). Pediatric obesity algorithm: a practical approach to obesity diagnosis and management. *Frontiers in Pediatrics*, 6, 431.
21. Davis, C. L., Tomporowski, P. D., McDowell, J. E., Austin, B. P., Miller, P. H., Yanasak, N. E., ... & Naglieri, J. A. (2011). Exercise improves executive function and achievement and alters brain activation in overweight children: A randomized, controlled trial. *Health Psychology*, 30(1), 91.
22. Deci, E. L., & Ryan, R. M. (1985a). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum Press.
23. Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227-268.
24. Deng, Y., Manninen, M., Hwang, Y., Kim, T., & Yli-Piipari, S. (in review, 2022). Efficacy of lifestyle interventions to prevent and treat pediatric obesity: A systematic review and meta-analysis.
25. Dietz, W., Lee, J., Wechsler, H., Malepati, S., & Sherry, B. (2007). Health plans' role in preventing overweight in children and adolescents. *Health Affairs*, 26(2), 430-440.
26. Epstein, L. H., Valoski, A., Wing, R. R., & McCurley, J. (1994). Ten-year outcomes of behavioral family-based treatment for childhood obesity. *Health Psychology*, 13(5), 373.
27. Fortier, M. S., Sweet, S. N., O'Sullivan, T. L., & Williams, G. C. (2007). A self-determination process model of physical activity adoption in the context of a randomized controlled trial. *Psychology of Sport and Exercise*, 8(5), 741-757.
28. Friedemann Smith, C., Heneghan, C., & Ward, A. (2015). Moving focus from weight to health. What Are the components used in interventions to improve cardiovascular health in children?. *PLoS One*, 10(8), e0135115.
29. Gilbert-Diamond, D., Li, Z., Adachi-Mejia, A. M., McClure, A. C., & Sargent, J. D. (2014). Association of a television in the bedroom with increased adiposity gain in a

- nationally representative sample of children and adolescents. *JAMA Pediatrics*, 168(5), 427-434.
30. Gilles, A., Cassano, M., Shepherd, E. J., Higgins, D., Hecker, J. E., & Nangle, D. W. (2008). Comparing active pediatric obesity treatments using meta-analysis. *Journal of Clinical Child & Adolescent Psychology*, 37(4), 886-892
 31. Golan, M., & Crow, S. (2004). Parents are key players in the prevention and treatment of weight-related problems. *Nutrition Reviews*, 62(1), 39-50.
 32. Gonzalez-Suarez, C., Worley, A., Grimmer-Somers, K., & Dones, V. (2009). School-based interventions on childhood obesity: A meta-analysis. *American Journal of Preventive Medicine*, 37(5), 418-427.
 33. Goodman, E., & Whitaker, R. C. (2002). A prospective study of the role of depression in the development and persistence of adolescent obesity. *Pediatrics*, 110(3), 497-504.
 34. Gustafson, S. L., & Rhodes, R. E. (2006). Parental correlates of physical activity in children and early adolescents. *Sports Medicine*, 36(1), 79-97.
 35. Ho, M., Garnett, S. P., Baur, L. A., Burrows, T., Stewart, L., Neve, M., & Collins, C. (2013). Impact of dietary and exercise interventions on weight change and metabolic outcomes in obese children and adolescents: A systematic review and meta-analysis of randomized trials. *JAMA Pediatrics*, 167(8), 759-768.
 36. Ho, M., Garnett, S. P., Baur, L., Burrows, T., Stewart, L., Neve, M., & Collins, C. (2012). Effectiveness of lifestyle interventions in child obesity: Systematic review with meta-analysis. *Pediatrics*, 130(6), e1647-e1671
 37. Hruby, A., & Hu, F. B. (2015). The epidemiology of obesity: A big picture. *Pharmacoeconomics*, 33(7), 673-689.
 38. Ismaeel, A., Weems, S., McClendon, M., & Morales, F. E. (2018). Interventions aimed at decreasing obesity in Hispanic children in the first 1000 days: A systematic review. *Journal of Immigrant and Minority Health*, 20(5), 1288-1293.
 39. Jackson, S. E., Llewellyn, C. H., & Smith, L. (2020). The obesity epidemic–Nature via nurture: A narrative review of high-income countries. *SAGE Open Medicine*, 8, 2050312120918265.
 40. Jakicic, J. M., Powell, K. E., Campbell, W. W., Dipietro, L., Pate, R. R., Pescatello, L. S., ... & 2018 Physical Activity Guidelines Advisory Committee. (2019). Physical activity and the prevention of weight gain in adults: A systematic review. *Medicine and Science in Sports and Exercise*, 51(6), 1262.
 41. Janssen, I., & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, 7(1), 1-16.
 42. Jensen, M. D., Ryan, D. H., Apovian, C. M., Ard, J. D., Comuzzie, A. G., Donato, K. A., ... & Yanovski, S. Z. (2014). 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults: A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society. *Journal of the American college of cardiology*, 63(25 Part B), 2985-3023.

43. Joschtel, B., Gomersall, S. R., Tweedy, S., Petsky, H., Chang, A. B., & Trost, S. G. (2018). Effects of exercise training on physical and psychosocial health in children with chronic respiratory disease: A systematic review and meta-analysis. *BMJ Open Sport & Exercise Medicine*, 4(1), e000409.
44. Kabali, H. K., Irigoyen, M. M., Nunez-Davis, R., Budacki, J. G., Mohanty, S. H., Leister, K. P., & Bonner Jr, R. L. (2015). Exposure and use of mobile media devices by young children. *Pediatrics*, 136(6), 1044-1050.
45. Kalarchian, M. A., Levine, M. D., Arslanian, S. A., Ewing, L. J., Houck, P. R., Cheng, Y., ... & Marcus, M. D. (2009). Family-based treatment of severe pediatric obesity: Randomized, controlled trial. *Pediatrics*, 124(4), 1060-1068.
46. Kalavainen, M. P., Korppi, M. O., & Nuutinen, O. M. (2007). Clinical efficacy of group-based treatment for childhood obesity compared with routinely given individual counseling. *International Journal of Obesity*, 31(10), 1500-1508.
47. Kamath, C. C., Vickers, K. S., Ehrlich, A., McGovern, L., Johnson, J., Singhal, V., ... & Montori, V. M. (2008). Behavioral interventions to prevent childhood obesity: A systematic review and meta-analyses of randomized trials. *The Journal of Clinical Endocrinology & Metabolism*, 93(12), 4606-4615.
48. Kasman, M., Hammond, R. A., Werman, A., Mack-Crane, A., & McKinnon, R. A. (2015). An in-depth look at the lifetime economic cost of obesity. *Brookings Institute*, 12.
49. Katz, D. L. (2009). School-based interventions for health promotion and weight control: Not just waiting on the world to change. *Annual Review of Public Health*, 30, 253-272.
50. Katz, I., Madjar, N., & Harari, A. (2015). Parental support and adolescent motivation for dieting: The self-determination theory perspective. *The Journal of Psychology*, 149(5), 461-479.
51. Klein, S., Allison, D. B., Heymsfield, S. B., Kelley, D. E., Leibel, R. L., Nonas, C., & Kahn, R. (2007). Waist circumference and cardiometabolic risk: A consensus statement from shaping America's health: Association for Weight Management and Obesity Prevention; NAASO, the Obesity Society; the American Society for Nutrition; and the American Diabetes Association. *The American Journal of Clinical Nutrition*, 85(5), 1197-1202.
52. Kuczmarski, R. J. (2000). *CDC growth charts: United States* (No. 314). US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics
53. Lake, J. K., Power, C., & Cole, T. J. (1997). Child to adult body mass index in the 1958 British birth cohort: Associations with parental obesity. *Archives of Disease in Childhood*, 77(5), 376-380.
54. LeBlanc, E. S., Patnode, C. D., Webber, E. M., Redmond, N., Rushkin, M., & O'Connor, E. A. (2018). Behavioral and pharmacotherapy weight loss interventions to prevent obesity-related morbidity and mortality in adults: Updated evidence report and systematic review for the US Preventive Services Task Force. *Jama*, 320(11), 1172-1191.
55. Lee, D. C., Pate, R. R., Lavie, C. J., Sui, X., Church, T. S., & Blair, S. N. (2014). Leisure-time running reduces all-cause and cardiovascular mortality risk. *Journal of the American College of Cardiology*, 64(5), 472-481.

56. LeMura, L. M., & Maziekas, M. T. (2002). Factors that alter body fat, body mass, and fat-free mass in pediatric obesity. In *Database of Abstracts of Reviews of Effects (DARE): Quality-assessed Reviews [Internet]*. Centre for Reviews and Dissemination (UK).
57. Lesinski, M., Herz, M., Schmelcher, A., & Granacher, U. (2020). Effects of resistance training on physical fitness in healthy children and adolescents: An umbrella review. *Sports Medicine*, 50(11), 1901-1928
58. Lindsay, R. S., Hanson, R. L., Roumain, J., Ravussin, E., Knowler, W. C., & Tataranni, P. A. (2001). Body mass index as a measure of adiposity in children and adolescents: Relationship to adiposity by dual energy x-ray absorptiometry and to cardiovascular risk factors. *The Journal of Clinical Endocrinology & Metabolism*, 86(9), 4061-4067.
59. Lipsky, L. M., & Iannotti, R. J. (2012). Associations of television viewing with eating behaviors in the 2009 health behaviour in school-aged children study. *Archives of Pediatrics & Adolescent Medicine*, 166(5), 465-472.
60. Llargues, E., Franco, R., Recasens, A., Nadal, A., Vila, M., Pérez, M. J., ... & Roure, E. (2011). Assessment of a school-based intervention in eating habits and physical activity in school children: The AVall study. *J Epidemiol Community Health*, 65(10), 896-901.
61. Lloyd-Richardson, E. E., Jelalian, E., Sato, A. F., Hart, C. N., Mehlenbeck, R., & Wing, R. R. (2012). Two-year follow-up of an adolescent behavioral weight control intervention. *Pediatrics*, 130(2), e281-e288.
62. Look AHEAD Research Group. (2013). Cardiovascular effects of intensive lifestyle intervention in type 2 diabetes. *New England Journal of Medicine*, 369(2), 145-154.
63. Luckner, H., Moss, J. R., & Gericke, C. A. (2012). Effectiveness of interventions to promote healthy weight in general populations of children and adults: A meta-analysis. *The European Journal of Public Health*, 22(4), 491-497.
64. Maes, H. H., Neale, M. C., & Eaves, L. J. (1997). Genetic and environmental factors in relative body weight and human adiposity. *Behavior Genetics*, 27(4), 325-351.
65. Malik, V. S., Pan, A., Willett, W. C., & Hu, F. B. (2013). Sugar-sweetened beverages and weight gain in children and adults: A systematic review and meta-analysis. *The American Journal of Clinical Nutrition*, 98(4), 1084-1102.
66. Mayr, H. L., Cohen, F., Isenring, E., Soenen, S., & Marshall, S. (2020). Multidisciplinary lifestyle intervention in children and adolescents-results of the project GRIT (Growth, Resilience, Insights, Thrive) pilot study. *BMC Pediatrics*, 20(1), 1-16.
67. McMurray, R. G., Harrell, J. S., Bangdiwala, S. I., Bradley, C. B., Deng, S., & Levine, A. (2002). A school-based intervention can reduce body fat and blood pressure in young adolescents. *Journal of Adolescent Health*, 31(2), 125-132.
68. McWhorter, J. W., Wallmann, H. W., & Alpert, P. T. (2003). The obese child: Motivation as a tool for exercise. *Journal of Pediatric Health Care*, 17(1), 11-17.
69. Metcalf, B., Henley, W., & Wilkin, T. (2012). Effectiveness of intervention on physical activity of children: Systematic review and meta-analysis of controlled trials with objectively measured outcomes. *Bmj*, 345.
70. Moncada-Jiménez, J., & Carazo-Vargas, P. (2015). A meta-analysis on the effects of exercise training on the VO2max in children and adolescents. *Retos. Nuevas tendencias en Educación Física, Deporte y Recreación*, (27), 184-187.

71. Nemet, D., Barkan, S., Epstein, Y., Friedland, O., Kowen, G., & Eliakim, A. (2005). Short-and long-term beneficial effects of a combined dietary–behavioral–physical activity intervention for the treatment of childhood obesity. *Pediatrics*, 115(4), e443-e449.
72. Oosterhoff, M., Joore, M., & Ferreira, I. (2016). The effects of school-based lifestyle interventions on body mass index and blood pressure: A multivariate multilevel meta-analysis of randomized controlled trials. *Obesity Reviews*, 17(11), 1131-1153.
73. Osei-Assibey, G., Dick, S., Macdiarmid, J., Semple, S., Reilly, J. J., Ellaway, A., ... & McNeill, G. (2012). The influence of the food environment on overweight and obesity in young children: A systematic review. *BMJ Open*, 2(6), e001538.
74. Oude Luttikhuis, H., Baur, L., Jansen, H., Shrewsbury, V. A., O'malley, C., Stolk, R. P., & Summerbell, C. D. (2009). Cochrane review: Interventions for treating obesity in children. *Evidence-Based Child Health: A Cochrane Review Journal*, 4(4), 1571-1729.
75. Pandita, A., Sharma, D., Pandita, D., Pawar, S., Tariq, M., & Kaul, A. (2016). Childhood obesity: Prevention is better than cure. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, 9, 83.
76. Patrick, H., & Nicklas, T. A. (2005). A review of family and social determinants of children's eating patterns and diet quality. *Journal of the American College of Nutrition*, 24(2), 83-92.
77. Patsopoulou, A., Tsimtsiou, Z., Katsioulis, A., Malissiova, E., Rachiotis, G., & Hadjichristodoulou, C. (2017). Evaluating the efficacy of the feeding exercise randomized trial in overweight and obese adolescents. *Childhood Obesity*, 13(2), 128-137.
78. Peirson, L., Fitzpatrick-Lewis, D., Morrison, K., Ciliska, D., Kenny, M., Ali, M. U., & Raina, P. (2015). Prevention of overweight and obesity in children and youth: A systematic review and meta-analysis. *Canadian Medical Association Open Access Journal*, 3(1), E23-E33.
79. Pelletier, L. G., & Dion, S. C. (2007). An examination of general and specific motivational mechanisms for the relations between body dissatisfaction and eating behaviors. *Journal of Social and Clinical Psychology*, 26(3), 303-333.
80. Phillips, C. M. (2013). Metabolically healthy obesity: Definitions, determinants and clinical implications. *Reviews in Endocrine and Metabolic Disorders*, 14(3), 219-227.
81. Principi, N., & Esposito, S. (2016). Antibiotic administration and the development of obesity in children. *International Journal of Antimicrobial Agents*, 47(3), 171-177.
82. Proctor, M. H., Moore, L. L., Gao, D., Cupples, L. A., Bradlee, M. L., Hood, M. Y., & Ellison, R. C. (2003). Television viewing and change in body fat from preschool to early adolescence: The framingham children's study. *International Journal of Obesity*, 27(7), 827-833.
83. Psaltopoulou, T., Tzanninis, S., Ntanas-Stathopoulos, I., Panotopoulos, G., Kostopoulou, M., Tzanninis, I. G., ... & Sargentanis, T. N. (2019). Prevention and treatment of childhood and adolescent obesity: A systematic review of meta-analyses. *World Journal of Pediatrics*, 1-32.

84. Rankin, J., Matthews, L., Cobley, S., Han, A., Sanders, R., Wiltshire, H. D., & Baker, J. S. (2016). Psychological consequences of childhood obesity: Psychiatric comorbidity and prevention. *Adolescent Health, Medicine and Therapeutics*, 7, 125.
85. Ranucci, C., Pippi, R., Buratta, L., Aiello, C., Gianfredi, V., Piana, N., ... & Mazzeschi, C. (2017). Effects of an intensive lifestyle intervention to treat overweight/obese children and adolescents. *BioMed Research International*, 2017.
86. Rosenheck, R. (2008). Fast food consumption and increased caloric intake: A systematic review of a trajectory towards weight gain and obesity risk. *Obesity Reviews*, 9(6), 535-547.
87. Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Publications.
88. Sackner-Bernstein, J., Kanter, D., & Kaul, S. (2015). Dietary intervention for overweight and obese adults: Comparison of low-carbohydrate and low-fat diets. A meta-analysis. *PloS one*, 10(10), e0139817.
89. Salam, R. A., Padhani, Z. A., Das, J. K., Shaikh, A. Y., Hoodbhoy, Z., Jeelani, S. M., ... & Bhutta, Z. A. (2020). Effects of lifestyle modification interventions to prevent and manage child and adolescent obesity: A systematic review and meta-analysis. *Nutrients*, 12(8), 2208.
90. Sallis, J. F., Owen, N., & Fisher, E. (2015). Ecological models of health behavior. *Health behavior: Theory, Research, and Practice*, 5(43-64).
91. Schranz, N., Tomkinson, G., & Olds, T. (2013). What is the effect of resistance training on the strength, body composition and psychosocial status of overweight and obese children and adolescents? A systematic review and meta-analysis. *Sports Medicine*, 43(9), 893-907.
92. Sgambato, M. R., Cunha, D. B., Souza, B. S., Henriques, V. T., Rodrigues, R. R., Rêgo, A. L., ... & Sichieri, R. (2019). Effectiveness of school-home intervention for adolescent obesity prevention: Parallel school randomised study. *British Journal of Nutrition*, 122(9), 1073-1080.
93. Sheldon, K. M., Williams, G., & Joiner, T. (2008). *Self-determination theory in the clinic: Motivating physical and mental health*. Yale University Press.
94. Skinner, A. C., Ravanbakht, S. N., Skelton, J. A., Perrin, E. M., & Armstrong, S. C. (2018). Prevalence of obesity and severe obesity in US children, 1999–2016. *Pediatrics*, 141(3).
95. Stettler, N., Signer, T. M., & Suter, P. M. (2004). Electronic games and environmental factors associated with childhood obesity in Switzerland. *Obesity Research*, 12(6), 896-903.
96. Stierman, B., Afful, J., Carroll, M. D., Chen, T. C., Davy, O., Fink, S., ... & Akinbami, L. J. (2021). National Health and Nutrition Examination Survey 2017–March 2020 Prepandemic Data Files Development of Files and Prevalence Estimates for Selected Health Outcomes.
97. Stommel, M., & Schoenborn, C. A. (2009). Accuracy and usefulness of BMI measures based on self-reported weight and height: Findings from the NHANES & NHIS 2001-2006. *BMC Public Health*, 9(1), 1-10.

98. Stoner, L., Rowlands, D., Morrison, A., Credeur, D., Hamlin, M., Gaffney, K., ... & Matheson, A. (2016). Efficacy of exercise intervention for weight loss in overweight and obese adolescents: Meta-analysis and implications. *Sports Medicine*, 46(11), 1737-1751.
99. Story, M., Neumark-Sztainer, D., & French, S. (2002). Individual and environmental influences on adolescent eating behaviors. *Journal of the American Dietetic Association*, 102(3), S40-S51.
100. Styne, D. M., Arslanian, S. A., Connor, E. L., Farooqi, I. S., Murad, M. H., Silverstein, J. H., & Yanovski, J. A. (2017). Pediatric obesity—assessment, treatment, and prevention: An Endocrine Society clinical practice guideline. *The Journal of Clinical Endocrinology & Metabolism*, 102(3), 709-757.
101. Tandon, P. S., Zhou, C., Sallis, J. F., Cain, K. L., Frank, L. D., & Saelens, B. E. (2012). Home environment relationships with children's physical activity, sedentary time, and screen time by socioeconomic status. *International Journal of Behavioral Nutrition and Physical Activity*, 9(1), 88.
102. Teixeira, P. J., Carraça, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, 9(1), 78.
103. Teixeira, P. J., Going, S. B., Houtkooper, L. B., Cussler, E. C., Metcalfe, L. L., Blew, R. M., ... & Lohman, T. G. (2006). Exercise motivation, eating, and body image variables as predictors of weight control. *Medicine & Science in Sports & Exercise*, 38(1), 179-188.
104. Thivel, D., Masurier, J., Baquet, G., Timmons, B. W., Pereira, B., Berthoin, S., ... & Aucouturier, J. (2018). High-intensity interval training in overweight and obese children and adolescents: Systematic review and meta-analysis. *The Journal of Sports Medicine and Physical Fitness*, 59(2), 310-324.
105. Thomas, J. G., Bond, D. S., Phelan, S., Hill, J. O., & Wing, R. R. (2014). Weight-loss maintenance for 10 years in the National Weight Control Registry. *American Journal of Preventive Medicine*, 46(1), 17-23.
106. Tremblay, M. S., LeBlanc, A. G., Kho, M. E., Saunders, T. J., Larouche, R., Colley, R. C., ... & Gorber, S. C. (2011). Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, 8(1), 98.
107. Vansteenkiste, M., Simons, J., Braet, C., Bachman, C., & Deci, E. L. (2005). Promoting maintained weight loss through healthy lifestyle changes among severely obese children: An experimental test of the self-determination theory.
108. Wadden, T. A., & Foster, G. D. (2000). Behavioral treatment of obesity. *Medical Clinics of North America*, 84(2), 441-461.
109. Wilfley, D. E., Tibbs, T. L., Van Buren, D., Reach, K. P., Walker, M. S., & Epstein, L. H. (2007). Lifestyle interventions in the treatment of childhood overweight: A meta-analytic review of randomized controlled trials. *Health Psychology*, 26(5), 521.
110. Williams, G. C., Grow, V. M., Freedman, Z. R., Ryan, R. M., & Deci, E. L. (1996). Motivational predictors of weight loss and weight-loss maintenance. *Journal of Personality and Social Psychology*, 70(1), 115.

111. Williams, G. C., McGregor, H. A., Zeldman, A., Freedman, Z. R., & Deci, E. L. (2004). Testing a self-determination theory process model for promoting glycemic control through diabetes self-management. *Health Psychology, 23*(1), 58.
112. World Health Organization. (2020). WHO guidelines on physical activity and sedentary behaviour: web annex: Evidence profiles.
113. Wyatt, S. B., Winters, K. P., & Dubbert, P. M. (2006). Overweight and obesity: Prevalence, consequences, and causes of a growing public health problem. *The American Journal of the Medical Sciences, 331*(4), 166-174
114. Yang, S., Qiu, L., Xiao, J., & Luo, C. (2021). The effects of resistance training on children with burns: A meta-analysis. *Pediatric Surgery International, 37*(10), 1323-1332.
115. Yli-Piipari, S., Berg, A., Laing, E. M., Hartzell, D. L., Parris, K. O., Udwadia, J., & Lewis, R. D. (2018). A twelve-week lifestyle program to improve cardiometabolic, behavioral, and psychological health in Hispanic children and adolescents. *The Journal of Alternative and Complementary Medicine, 24*(2), 132-1

CHAPTER III

EFFICACY OF LIFESTYLE INTERVENTIONS TO TREAT PEDIATRIC OBESITY: A SYSTEMATIC REVIEW AND META-ANALYSIS

¹Deng, Y., Manninen, M., Hwang, Y., Kim, T., & Yli-Piipari, S. To be submit to Obesity Review

3.1 Abstract

This study aimed to provide a quantitative synthesis of the effects of randomized controlled pediatric lifestyle interventions in treating obesity among 11- to 17-year-old children. We conducted a systematic review and meta-analysis on the randomized controlled trials published between January 2000 to January 2022. The initial search yielded 2,598 articles, with eight articles meeting the inclusion criteria. The articles were analyzed using a multivariate random effects model. The primary outcome variables were body mass index (BMI), standardized BMI (BMIZ), and waist circumference (WC). Our analyses showed that lifestyle interventions were efficacious in improving overweight and obese children's BMI (-1.77 kg/m^2 , 95% CI $[-2.65, -.88]$, $p < .001$), BMIZ ($-.30$, 95% CI $[-.44, -.17]$, $p < .001$), and WC (-3.72 cm , 95% CI $[-5.59, -1.85]$, $p < .001$). In addition, moderation analyses suggested that the lifestyle interventions were the most effective when participants were 13 to 15 years old and clearly obese. Our findings indicated that the effects of the lifestyle interventions were enhanced when an intervention was boosted with behavior modification components compared to the exercise-nutrition education-only interventions. In conclusion, our results indicate that lifestyle interventions are efficacious in treating overweight and obesity in adolescents. It can be recommended that the effectiveness of lifestyle interventions can be enhanced by including the behavior modification component to complement exercise and nutrition education components.

Keywords: Overweight, weight gain, adolescents

3.2 Introduction

The prevalence of pediatric obesity has been recognized as one of the major public health challenges of the 21st century (Skinner, Ravanbakht, Skelton, Perrin, & Armstrong, 2018; World Health Organization; 2020). Obesity prevalence has continued to rise through childhood (Abarca-Gómez et al., 2017; Mitchell, Catenacci, Wyatt, & Hill, 2011). This is a concern as childhood obesity is associated with a myriad of morbidities, e.g., cardiovascular diseases (Djalalinia, Qorbani, Peykari, & Kelishadi, 2015; Rankin et al., 2016), musculoskeletal disorders (Smith, Sumar & Dixon, 2014), type II diabetes mellitus (Hannon, Rao, & Arslanian, 2005), metabolic syndrome (Cardel, Atkinson, Taveras, Holm, & Kelly, 2020), and an increased likelihood of adverse psychological effects, e.g., depression, low perceived health-related quality of life, emotional and behavioral disorders, body dissatisfaction, and low self-esteem (Goodman & Whitaker, 2002; Peirson et al., 2015; Rankin et al., 2016; Wilmot et al., 2012). Although pediatric obesity is a global challenge, there are approximately 14.4 million obese children in the United States (US) alone (Fryar et al., 2020). This is problematic as the early development of overweight and obesity increases the risk of obesity in adulthood (Herman et al., 2009; Llewellyn, Simmonds, Owen, & Woolacott, 2016; Simmonds et al., 2015) and obesity has concerning economic ramifications on the US economy (Kasman, Hammond, Werman, Mack-Crane, & McKinnon, 2015). The estimated yearly economic cost of obesity in the US alone was nearly \$173 billion in 2019 (Ward, Bleich, Long, & Gortmaker, 2021).

Obesity is a complex and multifactorial disease, and it results from the interaction between environment, genetics, and an unhealthy lifestyle (Hruby & Hu, 2015; Jackson, Llewellyn, & Smith, 2020). Due to this complexity, prevention and treatment efforts for pediatric

obesity are as multi-leveled and complex as their causes. Thus, successful interventions to reduce obesity require a multi-component approach involving not only exercise and physical activity but also nutrition and dietary education (Brown et al., 2019; Ho et al., 2013). Previous research has found lifestyle interventions, i.e., interventions consisting of exercise, nutrition education, and behavior modifications, to be the preferred non-invasive strategy to prevent/treat pediatric obesity (Elvsaas, Giske, Fure, & Juvet, 2017; Psaltopoulou et al., 2019; Staniford, Breckon, & Copeland, 2012; Styne et al., 2017).

Several meta-analytic reviews have reported that lifestyle interventions can be effective in improving children and adolescents' weight status, body composition, physical activity, and dietary behaviors (Berge & Everts, 2011; Ho et al., 2012; Oude et al., 2009; Peirson et al., 2015; Wilfley et al., 2007). However, a recent meta-analysis by Hamid and Sazlina (2019) ($k = 14$, age range 9-12 years) reviewing the studies from 2000 to 2017 found that, on average, lifestyle interventions did not have a statistically significant effect on BMIz, WC, or body fat. Similarly, research has shown inconsistency in the efficacy of obesity interventions conducted in the school environment (Connelly, Duaso, & Butler, 2007, Cook-Cottone, Casey, Feeley, & Baran, 2009; Gonzalez-Suarez, Worley, Grimmer-Somers, & Dones, 2009; McMurray et al., 2002). For instance, a Connelly, Duaso, and Butler (2007) meta-analysis showed that 11 obesity trials were effective, whereas 17 were ineffective, in reducing obesity. The main factor distinguishing effective from ineffective trials is if the intervention included actual physical activity rather than the recommendation of being physically active. Similar conclusions can be drawn from the meta-analysis of McMurray et al. (2002) reviewing school-based obesity prevention studies. Their results showed no statistically significant changes in BMI but skinfold-measured fat reductions

and oxygen consumption (VO_2) max increases were greater in the combination of exercise and nutrition education group than in the education only or control groups.

Our review of the current literature exposed several gaps in knowledge that warrant this meta-analytic review. First, the findings from the previous meta-analyses are inconsistent with large heterogeneity in the sizes of effects (Kamath et al., 2008). This large heterogeneity may be partially due to the contents of different lifestyle interventions, as the interventions, have varied greatly based on frequency (once to several times per week), duration (a few weeks to years), and the number of intervention components (e.g., physical activity, nutrition education, and behavior modification). Second, a large portion of the published lifestyle interventions have not offered actual exercise training but exercise/physical activity recommendations or education about the benefits of exercise/physical activity. The Conelly, Duaso, and Butler (2007) and McMurray et al. (2002) meta-analyses show that including actual exercise, not a recommendation, is an important factor impacting the effectiveness of pediatric obesity interventions. Therefore, for this meta-analytic review, we included only interventions that comprise actual exercise training, as the effectiveness of “real” exercise vs. exercise recommendation is likely to be different.

This study aimed to summarize and examine the efficacy of randomized controlled pediatric lifestyle interventions (including the combination of exercise, nutrition education, and behavioral modification) in treating obesity among 11- to 17-year-old children. Specifically, our first aim was to examine the efficacy of pediatric lifestyle interventions on participants' BMI, BMIz, and WC among overweight or obese children. Our secondary aim was to identify whether

age, weight status, intervention type, frequency, or intervention duration moderated the efficaciousness of pediatric lifestyle interventions.

3.3 Methods

3.3.1 Literature search

This meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, and the study was pre-registered on the OSF-website (<https://osf.io/sjpg5/>). A systematic literature search was conducted for articles published from January 2000 to the end of January 2022, using the following academic databases: 1) PUBMED, 2) PsycINFO, 3) CINAHL, 4) Embase, 5) Cochrane Reviews, 6) ProQuest Dissertations and Theses, and 7) prepublications (OSF, preprint psycarxiv). The applied search terms were broad, including combinations and synonyms of ‘child/children’, ‘adolescence’, ‘lifestyle/family/community’, ‘obesity/weight loss/BMI/waist circumference’, and ‘intervention/ experiment/maintenance’. The search strategy was completed using an electronic database. Additional studies were retrieved from the manual search, including reference lists of the relevant studies retrieved using database searches and the reference lists of the previous reviews in this area.

3.3.2 Study selection

Articles were included if they met the following criteria: a) a randomized controlled trial with a minimum of two treatment components (i.e., actual exercise/physical activity, nutrition and healthy eating education, or behavior modification) treating or preventing obesity; b) early and middle adolescence with participant ages from 11 to 17; c) BMI of participants $\geq$ 85 percentile or $\geq$ 25 kg/m²; d) intervention took place in schools, primary care centers, hospitals, or other health

institutions; and e) the outcome measures were focused on BMI, BMIz, and/or WC. This review comprised interventions published prior to December 2021.

Exclusion criteria were: a) lifestyle interventions comprising surgeries or/and medications; b) age < 11 or age > 17 years old; c) prevention studies with normal weight participants; d) insufficient data available to complete the meta-analysis and authors were unable to provide the requested data; e) published in a language other than English.

Title, abstract, and keywords of identified papers were screened by independent reviewers, with three independent reviewers participating in the process. Citations and abstracts of all retrieved studies were downloaded to an excel file. After removing duplicates, another three independent reviewers screened all abstracts using the eligibility criteria. If the decision could not be made based on the abstract of the article, the full article was read to make the assessment. A full text screening was also conducted by three reviewers, and reasons for exclusions were recorded. A fourth reviewer was consulted to resolve conflicts at both phases of study selection.

3.3.3 Data collection process

A data extraction form was developed, informed by the PRISMA statement for reporting systematic reviews (Page et al., 2021). Two teams of coders (in total 4 coders) established and completed a data extraction coding procedure of study characteristics. Interrater reliability was .95. The extraction of the data comprised the first author's name, publication year, country of publication, number of effects, outcome information (BMI, BMIz, and WC), intervention (exercise and nutrition education duration, frequency, and length), and descriptive information about the sample, e.g., education background and weight status. Five studies had missing data

and the authors of those studies were contacted three times by email. If the authors provided the data, the article was included in this review. In case of no reply, the study was excluded from this review. In total, none of the contacted authors replied, so five studies were excluded from the data pool.

3.3.4 Risk of bias assessment

We used the Cochrane Collaboration's Tool (Higgins et al., 2019) for the risks of bias that were assessed at the study level, focusing on selection (random sequence generation and concealment of allocation methods), attrition (completeness of outcome data), detection (blinding of outcome assessors), performance (blinding of participants and personnel), and reporting (selective reporting of outcome measures). For each included study and type of bias, two reviewers independently ascribed a judgment for the risk of bias (low risk, high risk, unclear). Conflicting judgments (one judgment disagreement) were discussed to reach an agreement together with a third independent judge.

3.3.5 Synthesis of results

In the meta-analysis, the pooled effect size of lifestyle interventions on BMI, BMIz, and WC was estimated by multivariate meta-regression analyses. Statistical heterogeneity was tested by calculating parameters of I^2 and τ^2 statistics (Higgins, Thompson, Deeks, & Altman, 2003). The I^2 statistic measures the proportion of the variance that can be accounted for by true differences in the effect size. I^2 thresholds have been proposed based on the Cochrane Collaboration interpretation, with 25%, 50%, and 75% representing low, moderate, and high variance, respectively. In addition, a set of diagnostics e.g., cook's distance was conducted to identify potential outliers and influential cases which may influence observed heterogeneity

(Viechtbauer & Cheung, 2010). Publication biases were assessed by visually inspecting funnel plots of the mean changes. Begg's rank correlation and Egger's asymmetry tests (Egger, Smith, Schneider, & Minder, 1997) were conducted to provide a formal assessment of publication bias across studies. A *p*-value greater than .05 was considered a non-significant bias.

A priori determined moderators e.g., age, education, weight status, intervention type (a. exercise and diet or b. exercise, diet and behavior modification), frequency, and duration of the intervention, were used in a linear regression analysis as univariate independent variables to explain the possible heterogeneous effects of the outcomes. Multiple regression of the moderators and their interactions were not tested because of an inadequate number of effects for each outcome (Deeks, Higgins, & Altman, 2011). All analyses were performed with R (version 4.0.0) with the package 'dplyr, metafor, robumeta'.

3.4 Results

There were 2,589 abstracts screened for eligibility, and 1,180 duplicates were excluded (Figure 3.1). One hundred and two full-text articles were assessed, and 42 reviewed articles were deemed eligible for the full-text review. A further 34 studies were excluded after the careful assessment. The primary reasons for exclusion were an absence of a control group ($k = 8$), an absence of nutrition ($k = 5$) or exercise ($k = 5$) groups, and missing data and not receiving a response from the authors ($k = 6$). Finally, one protocol and one review paper were excluded, and three manuscripts did not meet the age eligibility. A total of eight studies were included in the meta-analysis (Figure 3.1).

3.4.1 Qualitative characteristics of included studies

The characteristics of all eight studies are presented in Table 3.1. A total of 2,598 participants were included in the systematic review. Study sample sizes ranged from 28 to 243. Three of the reviews were conducted in the US (Arlinghaus et al., 2019; Davis et al., 2009; Soltero et al., 2018), two in Germany (Ounis et al., 2010; Reinehr et al., 2010), one in Greece (Patsopoulou et al., 2017), one in Serbia (Plavsic et al., 2020), and one in Denmark (Larsen et al., 2015). Four studies recruited participants in schools (Arlinghaus et al., 2019; Larsen et al., 2016; Patsopoulou et al., 2017; Soltero et al., 2018), and two studies recruited using media and collaboration with medical practitioners (Plavsic et al., 2020; Reinehr et al., 2010). The recruitment methods of the other two studies were unknown (Davis et al., 2009; Ounis et al., 2010).

Per our inclusion criteria, all the studies incorporated at least two intervention components; exercise/physical activity and nutrition education. Five studies included three components (Arlinghaus et al., 2019; Davis et al., 2009; Larsen et al., 2015; Reinehr et al., 2010; Soltero et al., 2018). Four included studies that incorporated behavioral components (i.e., monitoring, goal setting, behavioral parenting skills, problem-solving, motivational interviewing), and three studies did not include a behavioral component (Davis et al., 2009; Ounis et al., 2010; Patsopoulou et al., 2017; Plavsic et al., 2020). The intervention design varied considerably. Intervention frequency ranged from one to seven times per week and duration from six weeks to 24 weeks. Four of the studies had follow-up measurements ranging from 12 to 52 weeks.

3.4.2 Risk of bias within studies

Table 3.2 presents a summary of the risk of bias within included studies. Overall, bias within studies was mostly low or unclear risk. All studies provided minimal information about potential selection bias. Information about random sequence generation and allocation concealment was missing in all studies, which resulted in labeling the risk of selection bias as ‘unclear’. Four of eight studies included did not report the method used to randomize participants. It is unknown whether participants in these studies were aware of the characteristics of the different treatments, which may have influenced the primary outcomes of the subsequent studies. Five of the nine studies included the intention to treat analyses of the primary outcomes. Most studies ($k = 6$) reported that individuals assessing body weight and height were blinded to the participants. Blinding of participants or personnel was judged as irrelevant in these trials assessed, as it was not possible to blind the participants or personnel of the intervention trials that comprise a specific intervention and “usual care” control groups.

3.4.3 Effects of the lifestyle intervention on BMI, BMIz, and WC

Multivariate meta-regression analyses showed statistically significant differences in BMI, BMIz, and WC. There were statistically significant reductions for the outcome variables ($Q = 210.24$, $df = 28$, $p < .001$). A set of diagnostics to identify potential outliers and influential cases are shown in Appendix 3.1-3.4. The analyses yield a statistically significant difference in BMI ($\beta = -1.77$ kg/m², 95% CI [-2.65, -.88], $p < .001$) favoring the intervention over control groups. Similar effects were observed for BMIz ($\beta = -.30$, 95% CI [-.44, -.17], $p < .001$) and WC (-3.72 cm, 95% CI [-5.59, -1.85], $p < .001$). Details of the forest plots showing the observed outcomes and estimates based on the random-effects and multivariate model are shown in Figures 3.2-3.4.

3.4.4 Moderator effects

A test of heterogeneity was conducted to determine the appropriateness of testing for the moderating effects. The statistically significant declines for BMI ($Q = 59.48$, $df = 7$, $p < .001$, $I^2 = 86.32\%$) and WC ($Q = 20.36$, $df = 4$, $p < .001$, $I^2 = 67.38\%$) were heterogeneous, suggesting a moderate-to-substantial heterogeneity. However, BMIz ($Q = 5.62$, $df = 4$, $p = .230$, $I^2 = 2\%$) was not heterogeneous. Overall, the significant Q statistics and high values of I^2 , indicates that the variability in the effects in BMI and WC did not occur based only on sampling errors.

The between-study variances in relation to possible moderators were pursued on BMI and WC. Five *a priori* determined moderators e.g., age, intervention type, weight, intervention frequency and duration were used in the multivariate analyses. The individual effect sizes and their CIs for the independent studies are presented in Table 3.3.

Analyses showed that age moderated the intervention effectiveness, with the largest reductions in BMI ($\beta = -2.60$ kg/m², CI 95% [-3.68, -1.52]) occurring during middle adolescence. In addition, the analyses indicated that obese adolescents gained the most advantageous benefits from the intervention as their BMI declined on average 2.34 kg/m² ($\beta = -2.34$, CI 95% [-3.43, -1.26]) and their WC reduced almost 3cm ($\beta = -2.99$, CI 95% [-4.49, -4.8]). Similarly, the intervention type had a moderating effect on WC, with larger reductions for interventions including behavior modification ($\beta = -3.67$, CI 95% [-5.35, -1.98]). Three types of interventions, e.g. exercise, nutrition education, and behavior modification, had higher efficacy compared to the two components approach (e.g., exercise and nutrition education). The analyses showed that intervention frequency was a statistically significant moderator. For the BMI, both ≤ 2 times per

week ($\beta = -1.52$, CI 95% [-2.12, -.92]) and ≥ 3 per week ($\beta = -1.64$, CI 95% [-2.45, -.83]) elicit reduction, while for WC, only ≥ 3 per week conducted interventions ($\beta = -5.05$, CI 95% [-7.11, -2.67]) trigger positive changes. Finally, there was a statistically significant moderator effect for duration. Both ≤ 12 weeks ($\beta = -2.09$, CI 95% [-2.52, -1.67]) and > 12 weeks long ($\beta = -3.33$, CI 95% [-4.80, -1.85]) interventions were statistically significant to reduce WC, but only > 12 weeks long intervention were effective enough to elicit changes in BMI ($\beta = -2.16$, CI 95% [-3.43, -.89]).

3.4. 5 Risk of bias across studies

An examination of standardized residuals revealed that none of the studies had values larger than ± 2.89 , and hence there was no indication of outliers in the context of this model. According to Cook's distance criteria, none of the studies could be considered to be overly influential (See Appendix 3.5). A funnel plot of the estimates is shown in Figure 3.4 and indicates a funnel plot symmetry for BMI and BMIz. In addition, neither the Egger's regression test (BMI; $p = .965$, BMIz; $p = .219$) nor Begg's rank correlation (BMI; $p = .826$, BMIz, $p = .720$) were statistically significant, corroborating the findings derived using the funnel plots. For WC, however, Egger's regression ($p < .010$) and Begg's rank tests ($p = .76$) suggest potential publication biases. The trim and fill method (see Supplementary Material) was used to increase funnel plot symmetry. In addition, a contour-enhanced funnel plot had plot symmetry, which indicates no publication bias (Figure 3.5).

3.5 Discussion

This meta-analytic review was conducted to evaluate the efficacy of pediatric lifestyle interventions on overweight and obese children's body composition. Due to the large

heterogeneity of the previously conducted pediatric lifestyle interventions, we aimed to use rigorous eligibility criteria and focus solely on pediatric lifestyle interventions including both exercise and nutrition education components and actual exercise training instead of exercise/physical activity recommendations. Our review found that lifestyle interventions had a moderate-to-large effect on BMI, BMIz, and WC. Moderator analyses suggested that intervention type, duration, and frequency, along with participant age and weight status were moderating the effectiveness of these lifestyle interventions.

Meta-analytic review confirmed that pediatric lifestyle interventions are effective in improving children's BMI. On average, children's participation in lifestyle interventions yielded a 1.77 kg/m² decline in participants' BMI. The size of this effect is similar to the findings of previous meta-analyses (effect range in BMI from -1.25 to -2.0 kg/m²; Berge & Everts, 2011; Stoner et al., 2016; Ho et al., 2012) that have applied broader eligibility criteria. Similarly, participants' BMIz and WC showed a .30 unit change and a 3.72 cm change for BMIz and WC, respectively. When compared to the effect sizes derived from the previous meta-analyses, the effect sizes of this meta-analysis were larger (Peirson et al., 2015; BMIz_{range} -.10 to -.03; Stoner et al., 2016; WC_{range} -1.3 to -4.8). Collectively, these findings suggest that lifestyle interventions including the combination of actual exercise, nutrition education, and/or behavior modification are an effective strategy to improve children's body composition and, as a result, reduce the risk for obesity-related diseases. It is noteworthy, that based on the findings of this study, lifestyle interventions with actual exercise can lead to larger effect sizes compared to the interventions consisting of only an exercise recommendation. This finding is logical as exercise adherence and

intensity are likely to be greater in actual exercise training compared to the exercise recommendation.

In regards to the moderator effects, our study showed that the age and weight status of the participants, as well as intervention type, frequency, and duration impacted intervention efficacy. Specifically, participants in middle adolescence, i.e., around 13-year old, and obese children gained the biggest benefits from the lifestyle interventions. These findings corroborate previous findings that have shown larger intervention effects for weight loss studies involving children above 12 years of age (Oude-Luttikhuis et al., 2009). Similarly, our study findings support the findings of previous studies that have shown longer-lasting interventions to be more effective in reducing BMI and WC (Bondyra-Wisniewska, Myszkowska-Ryciak, & Harton, 2021). Interestingly, our results showed that behavior modification enhanced lifestyle interventions were more effective in reducing children's WC compared to exercise and nutrition education interventions alone. This finding is consistent with previous findings which have shown that the combination of diet, exercise, and behavioral modification is the most effective non-invasive strategy for reducing adolescent obesity (Salam et al., 2020; Whitlock et al., 2010; Wilfley et al., 2007). Lifestyle interventions including behavior modification strategies, e.g., goal setting, behavioral therapy, or motivational strategies, can be considered as useful tools to enhance behavioral intervention efficacy. Our findings indicate that future research should examine which behavioral modification techniques are the most effective boosters to improve the efficacy of lifestyle interventions to reduce pediatric obesity. It should be noted that due to the small number of effects, and the heightened risk for type 1 error, we did not pursue additional univariate moderator analyses. For example, most of the reviewed trials were mixed-sex interventions, but

due to the aforementioned limitation, we could not test whether both sexes respond similarly to pediatric lifestyle interventions.

In summary, our meta-analysis clearly demonstrated that lifestyle interventions are impactful in reducing pediatric obesity. It is logical that the effectiveness of these interventions increases as the level of obesity gets greater, as obese individuals can lose more weight until reaching a healthy weight. Similarly, our study showed that longer interventions led to better outcomes. Finally, actual exercise and nutrition education intervention efficacy can be improved when combined with a behavior modification plan. It should be noted, however, that the reductions in the effect size heterogeneity derived from our moderator analyses were small, leaving much of the heterogeneity unexplained. This was mainly due to the small number of studies that met our eligibility criteria. Although our study indicated that the scope or the setting of the intervention is not a significant moderator, we cannot unequivocally determine that the scope or setting of the intervention are not important factors relating to lifestyle intervention efficacy. Second, we recommend that pediatric weight loss studies do not solely rely on weight measures as adolescents' height changes so dramatically during puberty. A combination of body composition measures with health-related fitness measures would help to create more valid snapshots of children's and adolescents' weight-related health.

3.5.1 Strengths & Limitations

There are several strengths associated with our study. First, it employed a comprehensive search strategy adhering to the PRISMA protocol, which is recommended strategy to ensure research integrity (Page et al., 2021). Second, this study employed strict eligibility criteria to focus on the most rigorously designed randomized controlled trials in the area of pediatric weight loss

lifestyle interventions. Finally, the multivariate random effects model provides a more solid analysis of the multiple outcomes variables by reducing type I errors.

The following limitations should be considered when interpreting the findings of this meta-analytic review. Despite the rigorous eligibility criteria, there was large heterogeneity in the effect sizes which limits the interpretation and generalizability of the findings. This large heterogeneity was due to the factors that related to insufficiencies in reporting study designs, implementation, and analyses. Second, due to the rigorous eligibility criteria, our sample size was relatively small ($k = 8$). Although our focus on the randomized controlled studies and lifestyle interventions including actual exercise (not allowing exercise/physical activity recommendations) reduced heterogeneity of effect sizes, it negatively impacted the available sample size and the statistical power to detect statistically significant moderator effects. Third, the risk of bias was unclear in many studies, primarily because of a lack of provided information. Future lifestyle intervention studies should pay close attention to reporting diligently information that relates to the evaluation of the risk of bias. Specifically, the Cochrane Collaboration Tool suggests reporting methods related to random sequence generation, allocation concealment, attrition bias, and detection bias to help to determine the risks of bias (Higgins et al., 2019). Finally, a limitation of the present review was that only published manuscripts in English were included in this review.

3.6 Conclusion

In conclusion, lifestyle interventions comprising of actual exercise training, nutrition education, and behavior modification had a moderate to large effect on BMI, BMIz, and WC. Moderator analyses suggested that the type of the intervention as well as participant age and weight status

moderated the effect of lifestyle interventions on BMI and WC. This meta-analysis suggested lifestyle interventions can be enhanced by including behavior modification components to complement traditional exercise and nutrition education lifestyle interventions.

3.7 Reference

1. A. Hamid, M. S., & Sazlina, S. G. (2019). Interventions for obesity among schoolchildren: A systematic review and meta-analyses. *PloS One*, 14(1), e0209746.
2. Abarca-Gómez, L., Abdeen, Z. A., Hamid, Z. A., Abu-Rmeileh, N. M., Acosta-Cazares, B., Acuin, C., ... & Cho, Y. (2017). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128· 9 million children, adolescents, and adults. *The Lancet*, 390(10113), 2627-2642.
3. Arlinghaus, K. R., O'Connor, D. P., & Johnston, C. A. (2019). Frequency of school-based intervention needed to improve weight outcomes of Mexican-American adolescents with overweight or obesity: A randomized controlled trial. *Pediatric Obesity*, 14(12), e12568.
4. Berge, J. M., & Everts, J. C. (2011). Family-based interventions targeting childhood obesity: A meta-analysis. *Childhood Obesity*, 7(2), 110-121.
5. Bondyra-Wisniewska, B., Myszkowska-Ryciak, J., & Harton, A. (2021). Impact of lifestyle intervention programs for children and adolescents with overweight or obesity on body weight and selected cardiometabolic factors—A systematic review. *International Journal of Environmental Research and Public Health*, 18(4), 2061
6. Brown, H. E., Atkin, A. J., Panter, J., Wong, G., Chinapaw, M. J., & Van Sluijs, E. M. F. (2016). Family-based interventions to increase physical activity in children: A systematic review, meta-analysis and realist synthesis. *Obesity Reviews*, 17(4), 345-360.
7. Cardel, M. I., Atkinson, M. A., Taveras, E. M., Holm, J. C., & Kelly, A. S. (2020). Obesity treatment among adolescents: a review of current evidence and future directions. *JAMA Pediatrics*, 174(6), 609-617.
8. Connelly, J. B., Duaso, M. J., & Butler, G. (2007). A systematic review of controlled trials of interventions to prevent childhood obesity and overweight: A realistic synthesis of the evidence. *Public Health*, 121(7), 510-517.
9. Cook-Cottone, C., Casey, C. M., Feeley, T. H., & Baran, J. (2009). A meta-analytic review of obesity prevention in the schools: 1997–2008. *Psychology in the Schools*, 46(8), 695-719.
10. Davis, J. N., Kelly, L. A., Lane, C. J., Ventura, E. E., Byrd-Williams, C. E., Alexandar, K. A., ... & Goran, M. I. (2009). Randomized control trial to improve adiposity and insulin resistance in overweight Latino adolescents. *Obesity*, 17(8), 1542-1548.
11. Deeks, J. J., Higgins, J. P. T., & Altman, D. G. (2011). Chapter 9: Analysing data and undertaking meta-analyses. In: J. P. T. Higgins & S. Green (Eds). *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0. The Cochrane Collaboration, 2011. www.cochrane-handbook.org

12. Djalalinia, S., Qorbani, M., Peykari, N., & Kelishadi, R. (2015). Health impacts of obesity. *Pakistan Journal of Medical Sciences*, 31(1), 239.
13. Egger, M., Smith, G. D., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *BMJ*, 315, 629–634.
14. Elvsaas, I. K. Ø., Giske, L., Fure, B., & Juvet, L. K. (2017). Multicomponent lifestyle interventions for treating overweight and obesity in children and adolescents: A systematic review and meta-analyses. *Journal of Obesity*, 2017.
15. Fryar, C. D., Carroll, M. D., & Afful, J. (2020). Prevalence of overweight, obesity, and severe obesity among adults aged 20 and over: United States, 1960–1962 through 2017–2018. *NCHS health e-stats*, 1-7.
16. Gonzalez-Suarez, C., Worley, A., Grimmer-Somers, K., & Dones, V. (2009). School-based interventions on childhood obesity: A meta-analysis. *American Journal of Preventive Medicine*, 37(5), 418-427.
17. Goodman, E., & Whitaker, R. C. (2002). A prospective study of the role of depression in the development and persistence of adolescent obesity. *Pediatrics*, 110(3), 497-504.
18. Hannon, T. S., Rao, G., & Arslanian, S. A. (2005). Childhood obesity and type 2 diabetes mellitus. *Pediatrics*, 116(2), 473-480.
19. Herman, K. M., Craig, C. L., Gauvin, L., & Katzmarzyk, P. T. (2009). Tracking of obesity and physical activity from childhood to adulthood: The physical activity longitudinal study. *International Journal of Pediatric Obesity*, 4(4), 281-288.
20. Higgins, J. P., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. A. (Eds.). (2019). *Cochrane handbook for systematic reviews of interventions*. John Wiley & Sons.
21. Ho, M., Garnett, S. P., Baur, L. A., Burrows, T., Stewart, L., Neve, M., & Collins, C. (2013). Impact of dietary and exercise interventions on weight change and metabolic outcomes in obese children and adolescents: A systematic review and meta-analysis of randomized trials. *JAMA Pediatrics*, 167(8), 759-768.
22. Ho, M., Garnett, S. P., Baur, L., Burrows, T., Stewart, L., Neve, M., & Collins, C. (2012). Effectiveness of lifestyle interventions in child obesity: Systematic review with meta-analysis. *Pediatrics*, 130(6), e1647-e1671.
23. Hruby, A., & Hu, F. B. (2015). The epidemiology of obesity: A big picture. *Pharmacoeconomics*, 33(7), 673-689.
24. Jackson, S. E., Llewellyn, C. H., & Smith, L. (2020). The obesity epidemic—Nature via nurture: A narrative review of high-income countries. *SAGE Open Medicine*, 8, 2050312120918265.
25. Kamath, C. C., Vickers, K. S., Ehrlich, A., McGovern, L., Johnson, J., Singhal, V., ... & Montori, V. M. (2008). Behavioral interventions to prevent childhood obesity: A systematic review and meta-analyses of randomized trials. *The Journal of Clinical Endocrinology & Metabolism*, 93(12), 4606-4615.
26. Kasman, M., Hammond, R. A., Werman, A., Mack-Crane, A., & McKinnon, R. A. (2015). An in-depth look at the lifetime economic cost of obesity. *Brookings Institute*, 12.

27. Larsen, K. T., Huang, T., Ried-Larsen, M., Andersen, L. B., Heidemann, M., & Møller, N. C. (2016). A multi-component day-camp weight-loss program is effective in reducing BMI in children after one year: A randomized controlled trial. *PLoS One*, 11(6), e0157182.
28. Llewellyn, A., Simmonds, M., Owen, C. G., & Woolacott, N. (2016). Childhood obesity as a predictor of morbidity in adulthood: A systematic review and meta-analysis. *Obesity Reviews*, 17(1), 56-67.
29. McMurray, R. G., Harrell, J. S., Bangdiwala, S. I., Bradley, C. B., Deng, S., & Levine, A. (2002). A school-based intervention can reduce body fat and blood pressure in young adolescents. *Journal of Adolescent Health*, 31(2), 125-132.
30. Mitchell, N. S., Catenacci, V. A., Wyatt, H. R., & Hill, J. O. (2011). Obesity: Overview of an epidemic. *Psychiatric Clinics*, 34(4), 717-732.
31. Oude Luttikhuis, H., Baur, L., Jansen, H., Shrewsbury, V. A., O'malley, C., Stolk, R. P., & Summerbell, C. D. (2009). Cochrane review: Interventions for treating obesity in children. *Evidence-Based Child Health: A Cochrane Review Journal*, 4(4), 1571-1729.
32. Ounis, O. B., Elloumi, M., Zouhal, H., Makni, E., Denguezli, M., Amri, M., ... & Tabka, Z. (2010). Effect of individualized exercise training combined with diet restriction on inflammatory markers and IGF-1/IGFBP-3 in obese children. *Annals of Nutrition and Metabolism*, 56(4), 260-266.
33. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Bmj*, 372.
34. Patsopoulou, A., Tsimtsiou, Z., Katsioulis, A., Malissiova, E., Rachiotis, G., & Hadjichristodoulou, C. (2017). Evaluating the efficacy of the feeding exercise randomized trial in overweight and obese adolescents. *Childhood Obesity*, 13(2), 128-137.
35. Peirson, L., Fitzpatrick-Lewis, D., Morrison, K., Ciliska, D., Kenny, M., Ali, M. U., & Raina, P. (2015). Prevention of overweight and obesity in children and youth: A systematic review and meta-analysis. *Canadian Medical Association Open Access Journal*, 3(1), E23-E33.
36. Plavsic, L., Knezevic, O. M., Sovtic, A., Minic, P., Vukovic, R., Mazibrada, I., ... & Macut, D. (2020). Effects of high-intensity interval training and nutrition advice on cardiometabolic markers and aerobic fitness in adolescent girls with obesity. *Applied Physiology, Nutrition, and Metabolism*, 45(3), 294-300.
37. Psaltopoulou, T., Tzanninis, S., Ntanasis-Stathopoulos, I., Panotopoulos, G., Kostopoulou, M., Tzanninis, I. G., ... & Sergeantanis, T. N. (2019). Prevention and treatment of childhood and adolescent obesity: A systematic review of meta-analyses. *World Journal of Pediatrics*, 1-32.
38. Rankin, J., Matthews, L., Cobley, S., Han, A., Sanders, R., Wiltshire, H. D., & Baker, J. S. (2016). Psychological consequences of childhood obesity: Psychiatric comorbidity and prevention. *Adolescent Health, Medicine and Therapeutics*, 7, 125.
39. Reinehr, T. (2013). Lifestyle intervention in childhood obesity: Changes and challenges. *Nature Reviews Endocrinology*, 9(10), 607-614

40. Reinehr, T., Schaefer, A., Winkel, K., Finne, E., Toschke, A. M., & Kolip, P. (2010). An effective lifestyle intervention in overweight children: Findings from a randomized controlled trial on “Obeldicks light”. *Clinical Nutrition*, 29(3), 331-336.
41. Salam, R. A., Padhani, Z. A., Das, J. K., Shaikh, A. Y., Hoodbhoy, Z., Jeelani, S. M., ... & Bhutta, Z. A. (2020). Effects of lifestyle modification interventions to prevent and manage child and adolescent obesity: A systematic review and meta-analysis. *Nutrients*, 12(8), 2208.
42. Simmonds, M., Burch, J., Llewellyn, A., Griffiths, C., Yang, H., Owen, C., ... & Woolacott, N. (2015). The use of measures of obesity in childhood for predicting obesity and the development of obesity-related diseases in adulthood: A systematic review and meta-analysis. *Health Technology assessment (Winchester, England)*, 19(43), 1-336.
43. Skinner, A. C., Ravanbakht, S. N., Skelton, J. A., Perrin, E. M., & Armstrong, S. C. (2018). Prevalence of obesity and severe obesity in US children, 1999–2016. *Pediatrics*, 141(3).
44. Smith, S. M., Sumar, B., & Dixon, K. A. (2014). Musculoskeletal pain in overweight and obese children. *International Journal of Obesity*, 38(1), 11-15.
45. Soltero, E. G., Olson, M. L., Williams, A. N., Konopken, Y. P., Castro, F. G., Arcoleo, K. J., ... & Shaibi, G. Q. (2018). Effects of a community-based diabetes prevention program for Latino youth with obesity: A randomized controlled trial. *Obesity*, 26(12), 1856-1865.
46. Staniford, L. J., Breckon, J. D., & Copeland, R. J. (2012). Treatment of childhood obesity: A systematic review. *Journal of Child and Family Studies*, 21(4), 545-564.
47. Stoner, L., Rowlands, D., Morrison, A., Credeur, D., Hamlin, M., Gaffney, K., ... & Matheson, A. (2016). Efficacy of exercise intervention for weight loss in overweight and obese adolescents: Meta-analysis and implications. *Sports Medicine*, 46(11), 1737-1751.
48. Styne, D. M., Arslanian, S. A., Connor, E. L., Farooqi, I. S., Murad, M. H., Silverstein, J. H., & Yanovski, J. A. (2017). Pediatric obesity—assessment, treatment, and prevention: An Endocrine Society Clinical Practice guideline. *The Journal of Clinical Endocrinology & Metabolism*, 102(3), 709-757.
49. Viechtbauer, W., & Cheung, M. W. L. (2010). Outlier and influence diagnostics for meta-analysis. *Research Synthesis Methods*, 1(2), 112-125.
50. Ward, Z. J., Bleich, S. N., Long, M. W., & Gortmaker, S. L. (2021). Association of body mass index with health care expenditures in the United States by age and sex. *PloS One*, 16(3), e0247307.
51. Whitlock, E. P., O'Connor, E. A., Williams, S. B., Beil, T. L., & Lutz, K. W. (2010). Effectiveness of weight management interventions in children: A targeted systematic review for the USPSTF. *Pediatrics*, 125(2), e396-e418.
52. Wilfley, D. E., Tibbs, T. L., Van Buren, D., Reach, K. P., Walker, M. S., & Epstein, L. H. (2007). Lifestyle interventions in the treatment of childhood overweight: A meta-analytic review of randomized controlled trials. *Health Psychology*, 26(5), 521.
53. Wilmot, E. G., Edwardson, C. L., Achana, F. A., Davies, M. J., Gorely, T., Gray, L. J., ... & Biddle, S. J. (2012). Sedentary time in adults and the association with diabetes,

- cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia*, 55(11), 2895-2905.
54. World Health Organization. 2020. Obesity and overweight: key facts. <https://www.who.int/newsroom/fact-sheets/detail/obesity-and-overweight>. Published April 2020.

Table 3.1. Characteristics of Included Studies: Results for BMI, BMIz and WC Outcomes

First author (year), country	N	Characteristics	Intervention/comparator	Intervention duration	Outcomes	Main results
Arlinghaus et al., (2019), United States	243	Age: 12.02 ± 0.57 Gender: M: 100/203; F: 103/203 Ethnicity: Mexican-American Education: 6 th -7 th grade Inclusion: overweight or obesity (i.e., BMI percentile ≥ 85 th percentile)	Intervention: exercise, nutrition and behavior modification, (0,1,3,5 days a week), 80% of time was spent on physical activity, and 20% was spent on nutrition Exercise: circuit-based physical activity Nutrition (e.g., traffic light diet) Behavior modification: (e.g., token economy system, goal setting, and self-monitoring) Comparator: No intervention Parental involvement: Yes	Intervention: 24 weeks Follow-up: None	BMI BMIz WC	Both the 3-and 5-d/week groups had significantly greater reductions in BMI and BMIz than the intervention control.
Davis et al., (2009), United State	54	Age: 15.5 ± 1.00 Gender: M: 28/54; F: 26/54 Ethnicity: Latino Inclusion: overweight or obesity (i.e., BMI percentile ≥ 85 th percentile)	Intervention: nutrition (once per week, 60 min) and strength training (twice per week, 60 minutes), and motivational interview Nutrition: Veronica Atkins (e.g., added sugar <10% total calorie in take) Exercise: Resistance training Behavioral components: No	Intervention: 16 weeks Follow-up: None	BMI BMIz	There were no statistically significant effects on BMI and BMIz.

			Comparator: No intervention Parental involvement: No			
Larsen et al., (2016), Demark	106	Age: 12.0± 0.40 Gender: M: 47/106 F: 50/106 Ethnicity: unknown Inclusion: overweight or obesity (i.e., BMI percentile $\geq 85^{\text{th}}$ percentile)	Intervention: Physical activity (7 days/week, 180 minutes), health diet (7 days/week, 60 minutes) and behavior modification Exercise: (e.g., dancing, team building) Nutrition: (e.g., health cook classes) Behavior modification: (e.g., theory and behavior changes) Comparator: standard intervention arm Parental involvement: No	Intervention: 6 weeks Follow-up: 52 weeks	BMI BMIz WC	After 6 weeks, there were statistically significant improvements in BMI. After 52 weeks, the intervention group have lower BMI and BMIz score.
Ounis et al., (2010) Germany	28	Age: 13.2±0.70 Gender: M: 14/28 F: 14/28 Ethnicity: NA Inclusion: obesity (i.e., BMI percentile $\geq 97^{\text{th}}$ percentile)	Intervention: physical activity (4 days/week, 90 minutes) and dietary (1 days/week, 240 minutes). Physical activity: (e.g., warming up, running, jumping, and playing with a balloon) Dietary: (e.g., health food restriction education) Behavioral components: No Comparator: No intervention Parental involvement: No	Intervention: 8 weeks, Follow-up: No	BMI	There was a statistically significant reduction in BMI.

Patsopoulou et al., (2017), Greece	181	Age: 14.04±0.80 Gender: M: 47/106 F: 50/106 Ethnicity: NA Inclusion: overweight or obesity (i.e., BMI percentile $\geq 85^{\text{th}}$ percentile)	Intervention: physical activity (3 days/week, 45 minutes) and dietary (3 days/week, 15 minutes). Physical activity: (e.g., 50% team sports and 50% running games) Dietary: (e.g., cooking habits, general information about obesity) Behavioral components: No Parental involvement: Yes	Intervention: 24 weeks Follow-up: 12 weeks	BMI WC	There were statistically significant reductions in BMI, and WC.
Plavsic et al., (2020), Serbia	44	Age: 15.5± 1.50 Gender: unknown Ethnicity: NA Inclusion: overweight or obesity (i.e., BMI percentile $\geq 85^{\text{th}}$ percentile)	Intervention: exercise (2 days/week, 43 minutes) dietary (0.5 times/week, 20-30) Exercise (walking or running) Dietary: nutrition education Behavioral components: No Comparator: No intervention Parental involvement: Yes	Intervention: 12 weeks Follow-up: 12 weeks	BMI BMIz WC	There were a statistically significant improvements in BMI, BMIz and WC.
Reinehr et al., (2009), Germany	66	Age: 11.5 ± 1.60 Gender: M: 40/66; F: 60/66 Ethnicity: NA Inclusion: overweight or obesity (i.e., BMI percentile $\geq 85^{\text{th}}$ percentile)	Intervention: physical activity (1 day/ week 90 minutes) and nutrition education (30 minutes) and behavior counselling Physical activity: (e.g., ball game, jogging, trampoline jumping)	Intervention: 24 weeks Follow-up: No	BMI WC	

			Nutrition education: Optimized mixed diet, and traffic light behavior counselling: (e.g, systemic and solution-focused theories) Comparator: No intervention Parental involvement: No			
Soltero et al., (2018), United State	136	Age: 15.3 ± 1.09 Gender: M: 62/136; F: 74/136 Ethnicity: Latino Inclusion: obesity (i.e., BMI percentile ≥ 95th percentile	Intervention: nutrition (1 day/week, 60 minutes), exercise (3 days/week, 60 minutes) and Behavior modification. Nutrition: nutrition education Exercise: aerobic activities, anaerobic activity, and resistance exercise Behavior modification: goal setting, self-modification Comparator: No intervention Parental involvement: Yes	Intervention: 12 weeks Follow-up: 48 weeks	BMI WC	There was a statistically significant reduction in BMI and WC.

Table 3.2. Risk of Bias Summary for Bias within Included Studies

First author, citation	Random sequence generation		Allocation concealment		Attrition bias		Detection bias	
	Cochrane Judgement	Supporting evidence	Cochrane Judgement	Supporting evidence	Cochrane Judgement	Supporting evidence	Cochrane Judgement	Supporting evidence
Arlinghaus et al., (2019)	Low risk	A random number table was used to randomize the participants	Low risk	Generation of random sequence and enrollment conducted by research staff	Low risk	No participants drop out from the study	Low risk	Assessors were blinded to allocation
Davis et al., (2009)	Unclear	Method of randomization is not stated, but used. Randomization was blocked by gender	Unclear	Method not described	Unclear	Intention to treat analysis performed by assigning dropout (intervention 5/22; control 6/22)	Low risk	Assessors were blinded to allocation
Larsen et al., (2016)	Unclear	Method of randomization is not stated, but used. 1:1 ratio (intervention: control)	Unclear	Method not described	Low risk	Intention to treat analysis performed by assigning dropout (intervention 4/59; control 5/56)	Low risk	Assessors were blinded to allocation
Ounis et al., (2010)	Unclear	Method of randomization is not stated, but used.	Unclear	Method not described	Low risk	No participants drop out from the study	Unclear	Statement not described

Patsopoulou et al., (2017)	Unclear	Method of randomization is not stated, but used.	Unclear	Method not described	Low risk	Intention to treat analysis performed by assigning dropout (intervention 5/61; control 5/60)	Low risk	Assessors were blinded to allocation
Plavsic et al., (2019)	Low risk	Matched-paired block randomization using Excel 2013(Microsoft, Redmond, Wash., USA)	Low risk	Generation of random sequence and enrollment conducted by independent doctor	Low risk	Intention to treat analysis performed by assigning dropout (intervention 3/22; control 2/22)	Unclear	Statement not described
Reinehr et al., (2009)	Low risk	Computer generated the random sequence	Low risk	Method not described	Low risk	Intention to treat analysis performed by assigning dropout (intervention 5/39; control 5/37)	Low risk	Assessors were blinded to allocation
Soltero et al., (2018)	Low risk	SPSS statistics software (Version 21; IBM Corp., Armonk., New York) generated the random sequence	Low risk	Generation of random sequence and enrollment conducted by Research staff	Low risk	Intention to treat analysis performed by assigning dropout (intervention 8/67; control 4/69)	Low risk	Assessors were blinded to allocation

Table 3.3. Univariate Moderator Analysis BMI and WC

	BMI		WC	
	k	β (95% CI)	k	β (95%CI)
Age				
Age >13	5	.34(-1.56, 2.24)	NA	NA
Age 13<15	5	-2.60(-3.68, -1.52) ***	3	-6.00 (-9.14, -2.85) ***
Age>15	5	1.07(-.53, 2.68)	3	4.2(-1.56, 9.96)
Weight Status				
Overweight participants	8	-.65(-.99, 2.30)	5	-2.31(-5.00, .38)
Obese participants	8	-2.34(-3.43, -1.26)***	5	-2.99(-4.49, -4.8)***
Intervention type				
Exercise +nutrition	8	-1.42(-3.05, .10)	5	-1.52(-3.94, .88)
Exercise +nutrition+	8	-.36 (-2.22,1.50)	5	-3.67(-5.35, -1.98)***
Behavior modification				
Frequency (times/per week)				
≤ 2 times	5	-1.52(-2.12, -.92) ***	3	-5.05(-7.11, -2.98) ***
≥ 3 times	5	-1.64 (-2.45, -.83) ***	3	-.05 (-2.77, -2.67)
Duration (total weeks)				
≤ 12 weeks	6	-2.16(-3.43, -.89) ***	3	-2.09(-2.52, -1.67) ***
≥ 12 weeks	6	.17(-1.51, 1.86)	3	-3.33(-4.80, -1.85) ***

Note *** $p < .001$, ** $p < .01$, * $p < .05$

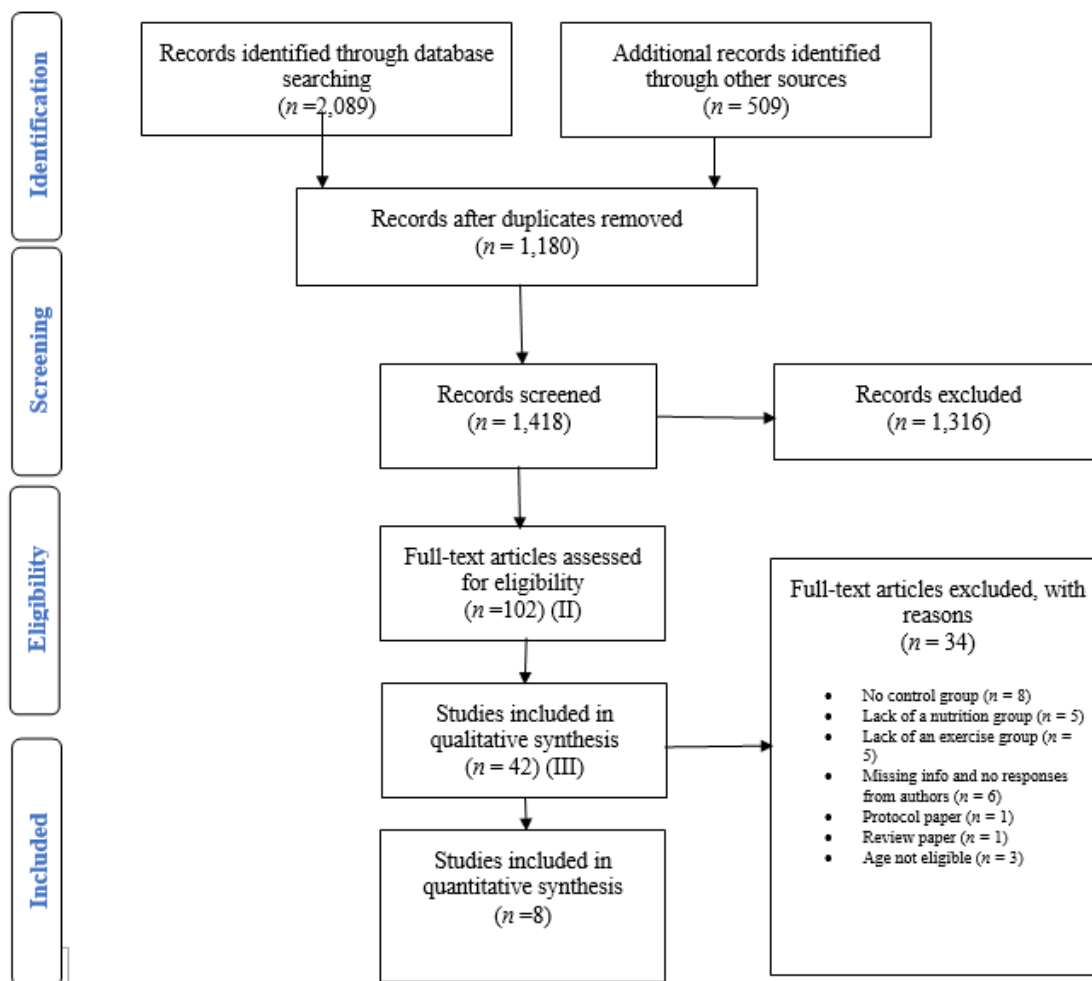


Figure 3.1. PRISMA 2020 flow diagram

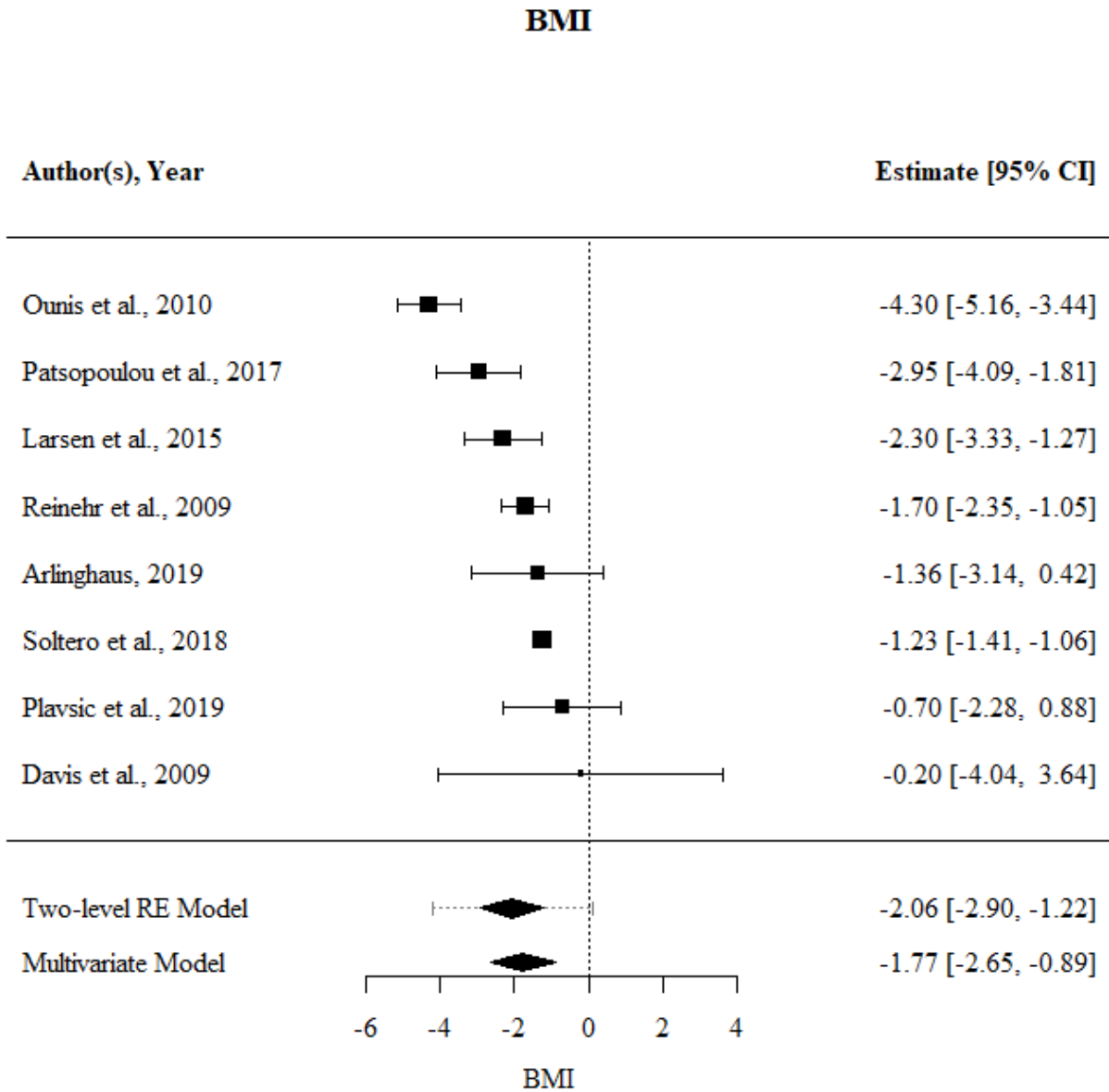


Figure 3.2. Forest plots for BMI

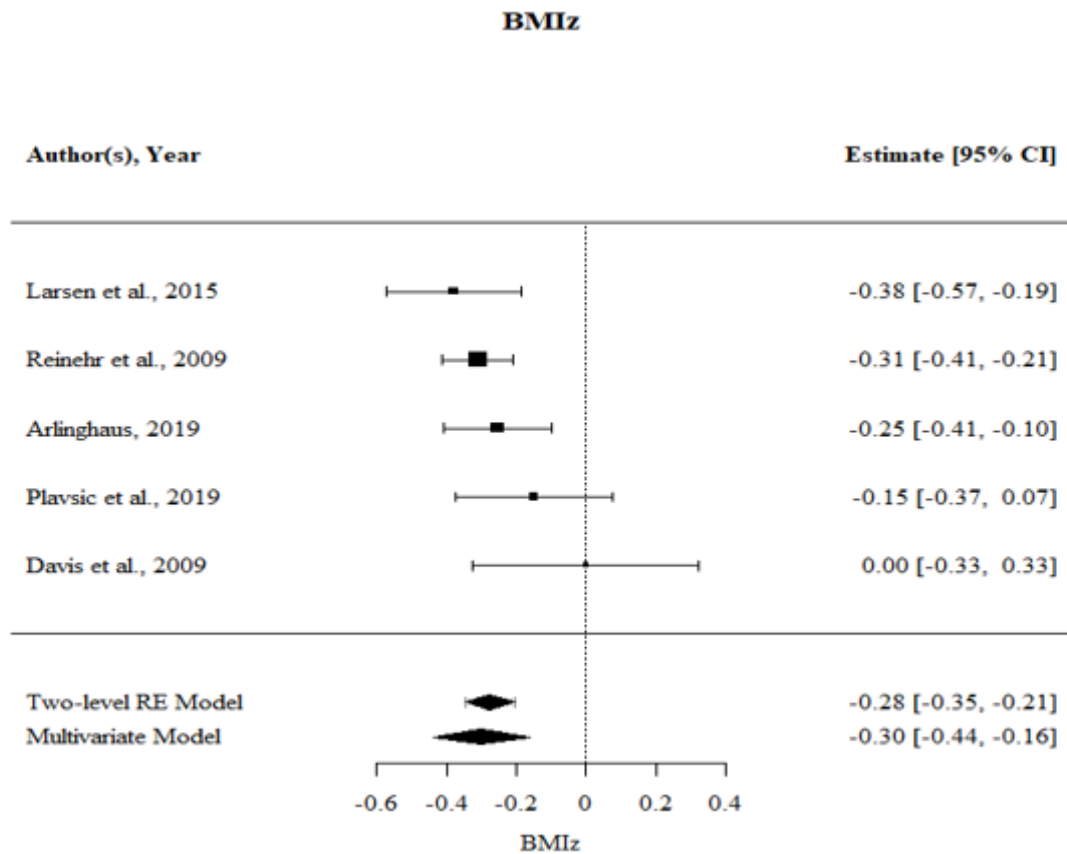


Figure 3.3. Forest plot for BMIz

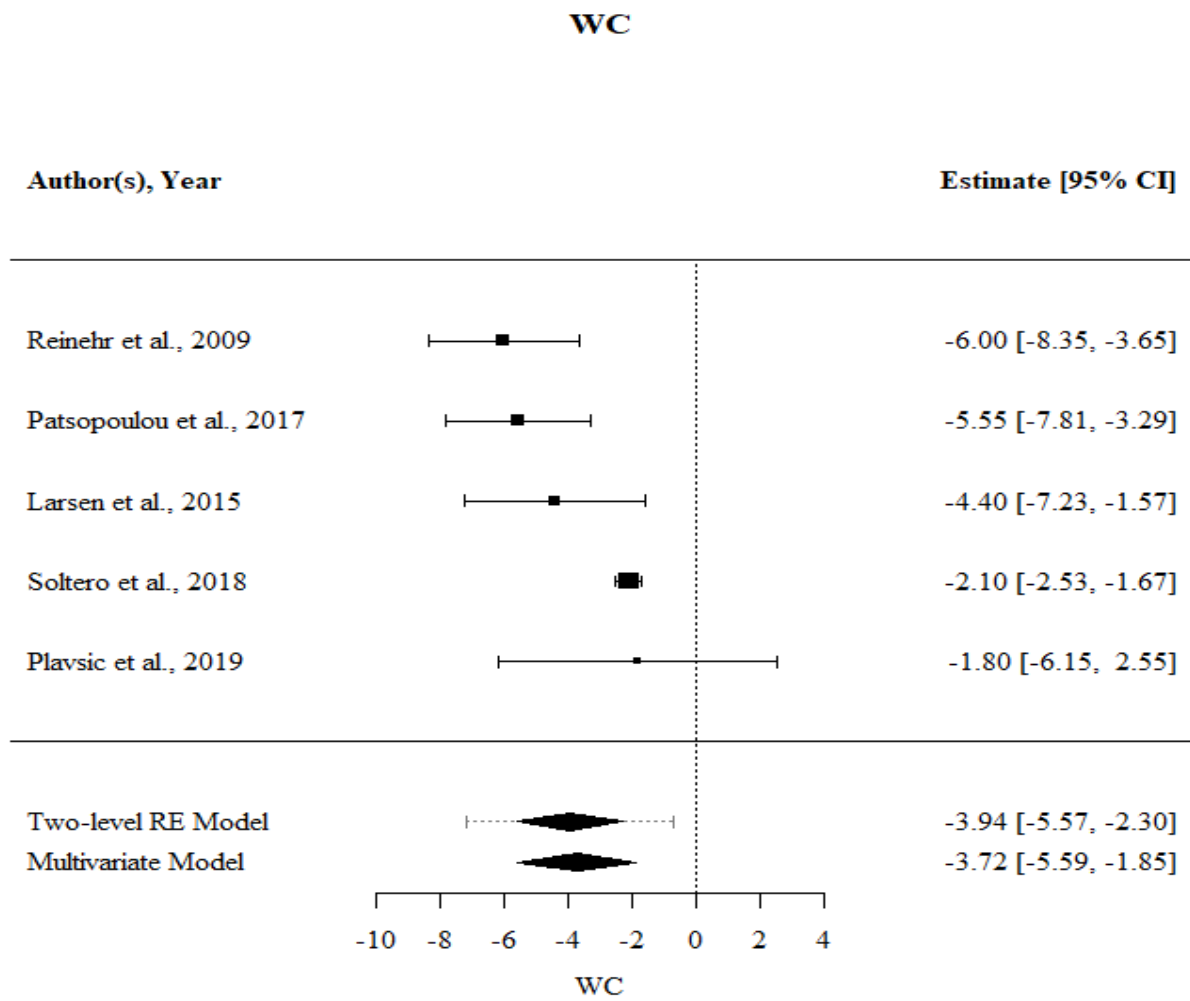


Figure 3.4. Forest plot for WC

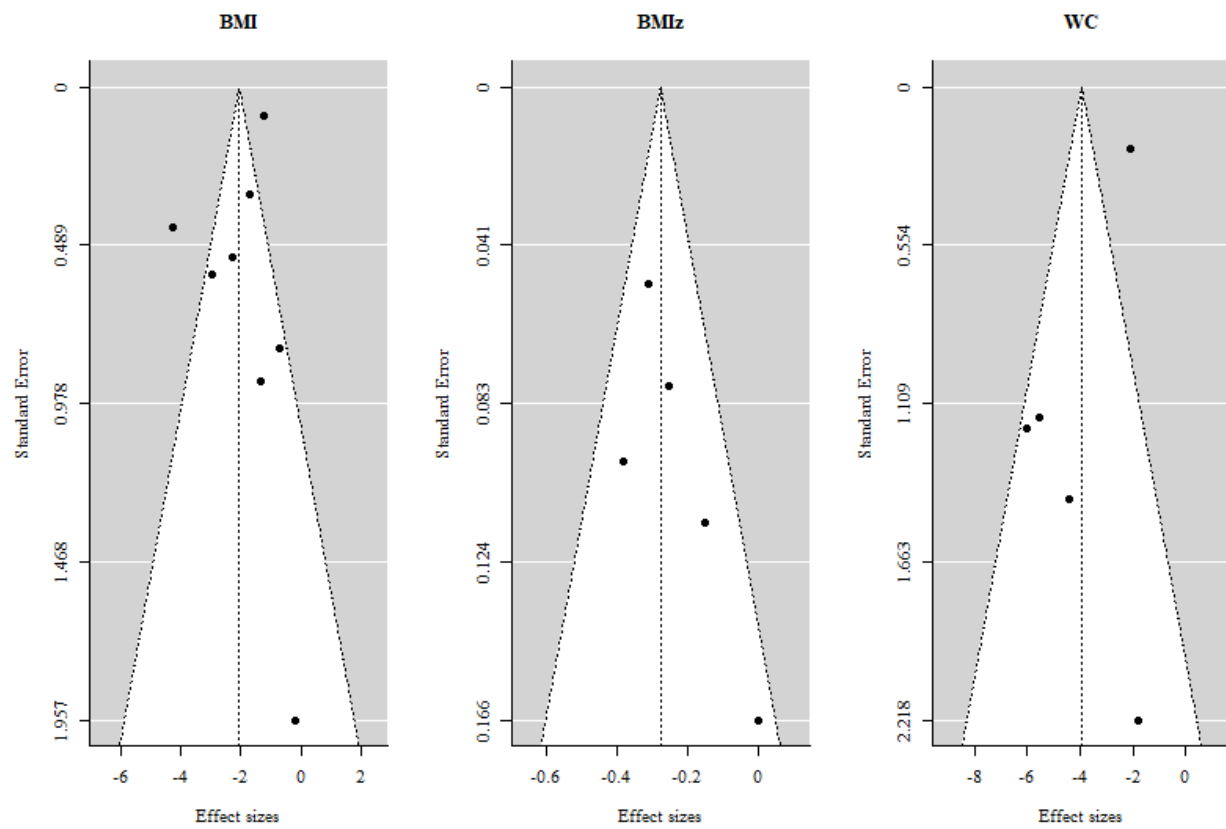


Figure 3.5. Funnel plot for risk of publication bias

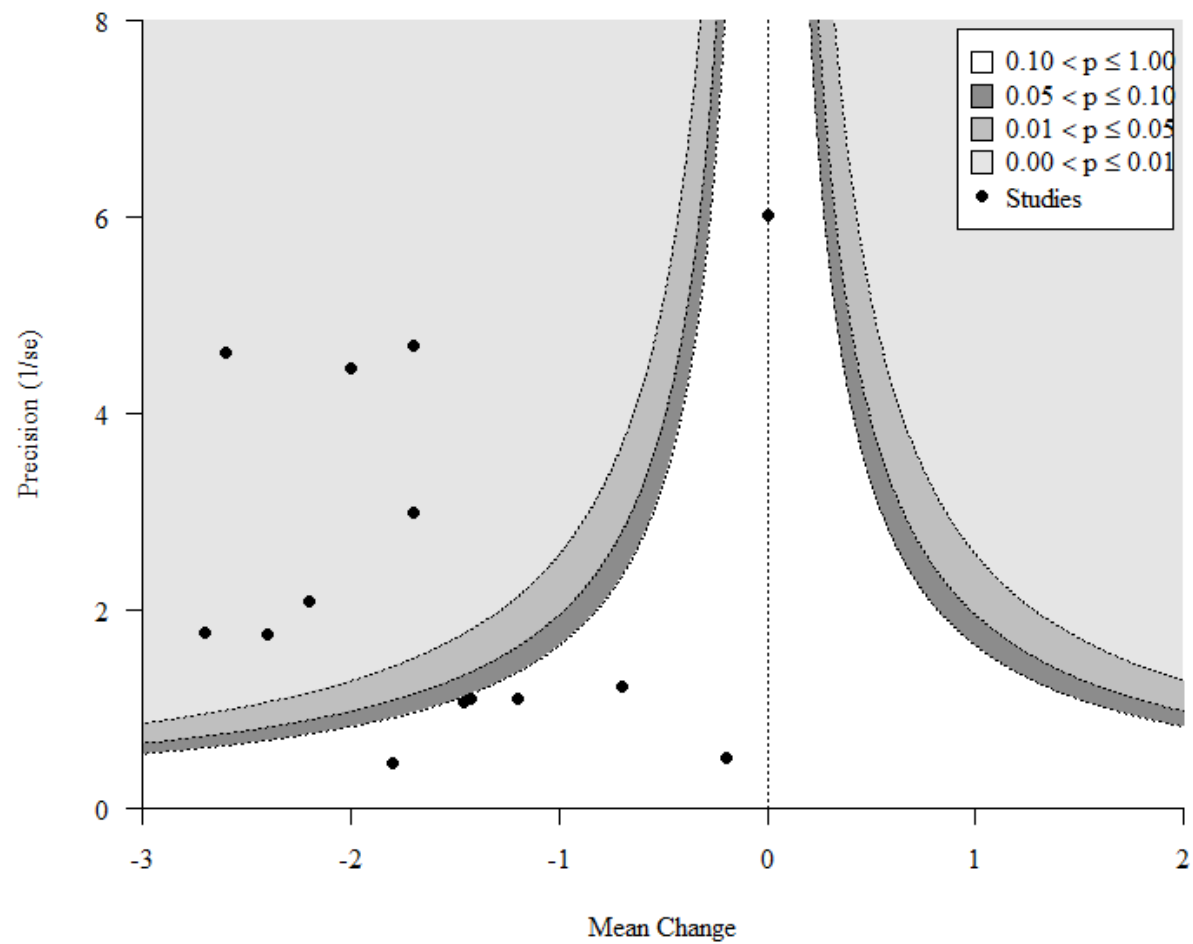


Figure 3.6. Contour-enhanced funnel plot for risk of publication bias

Appendix

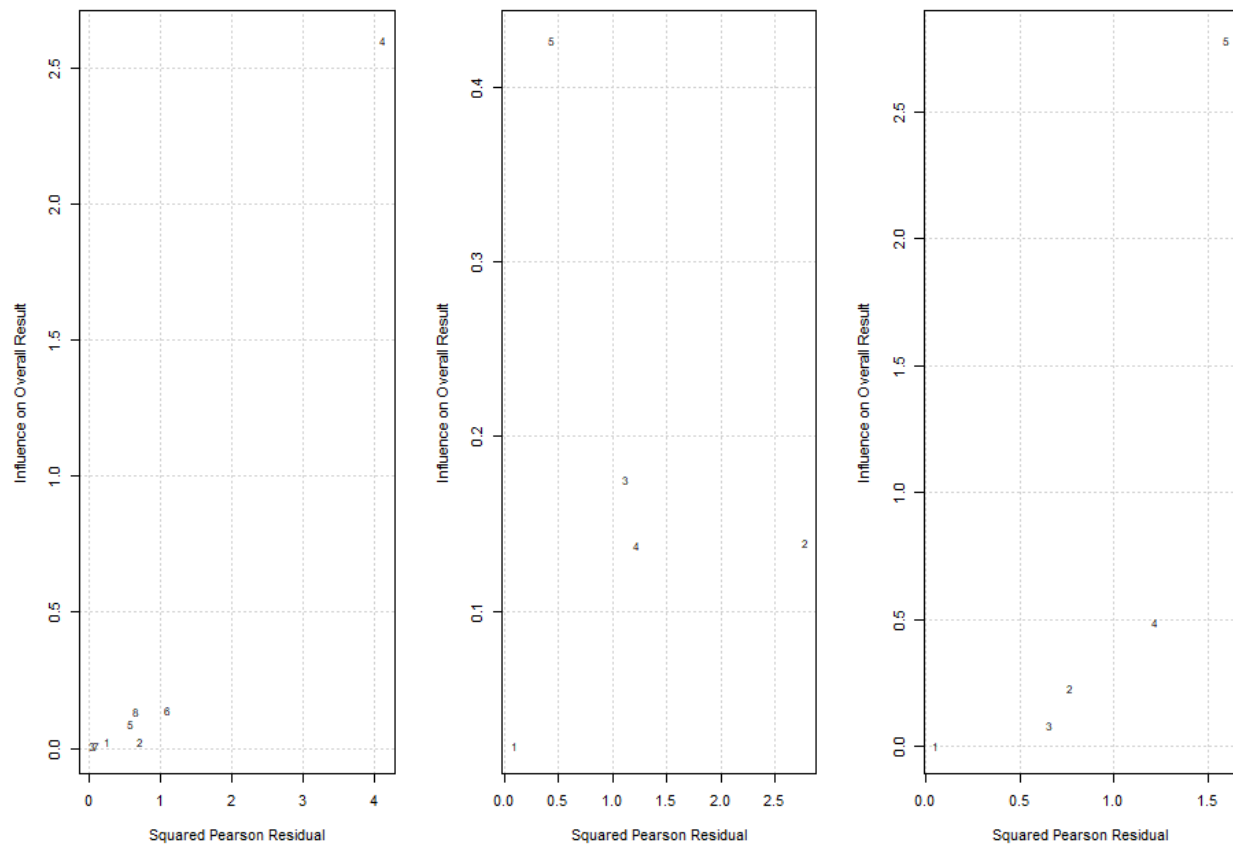


Figure 3.1. Outcome variable BMI, BMIZ, and WC diagnose plots

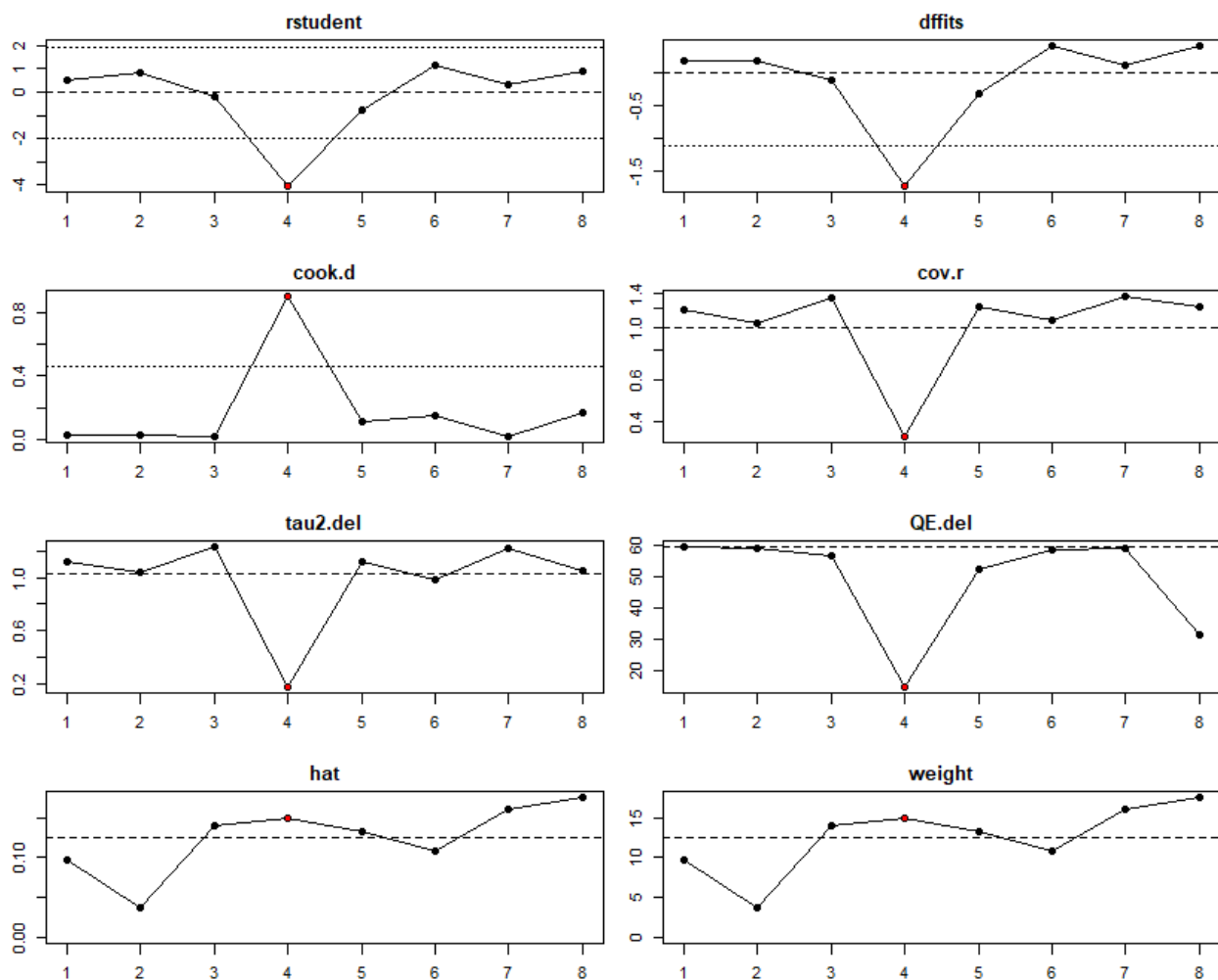


Figure 3.2. BMI diagnose outlier plot

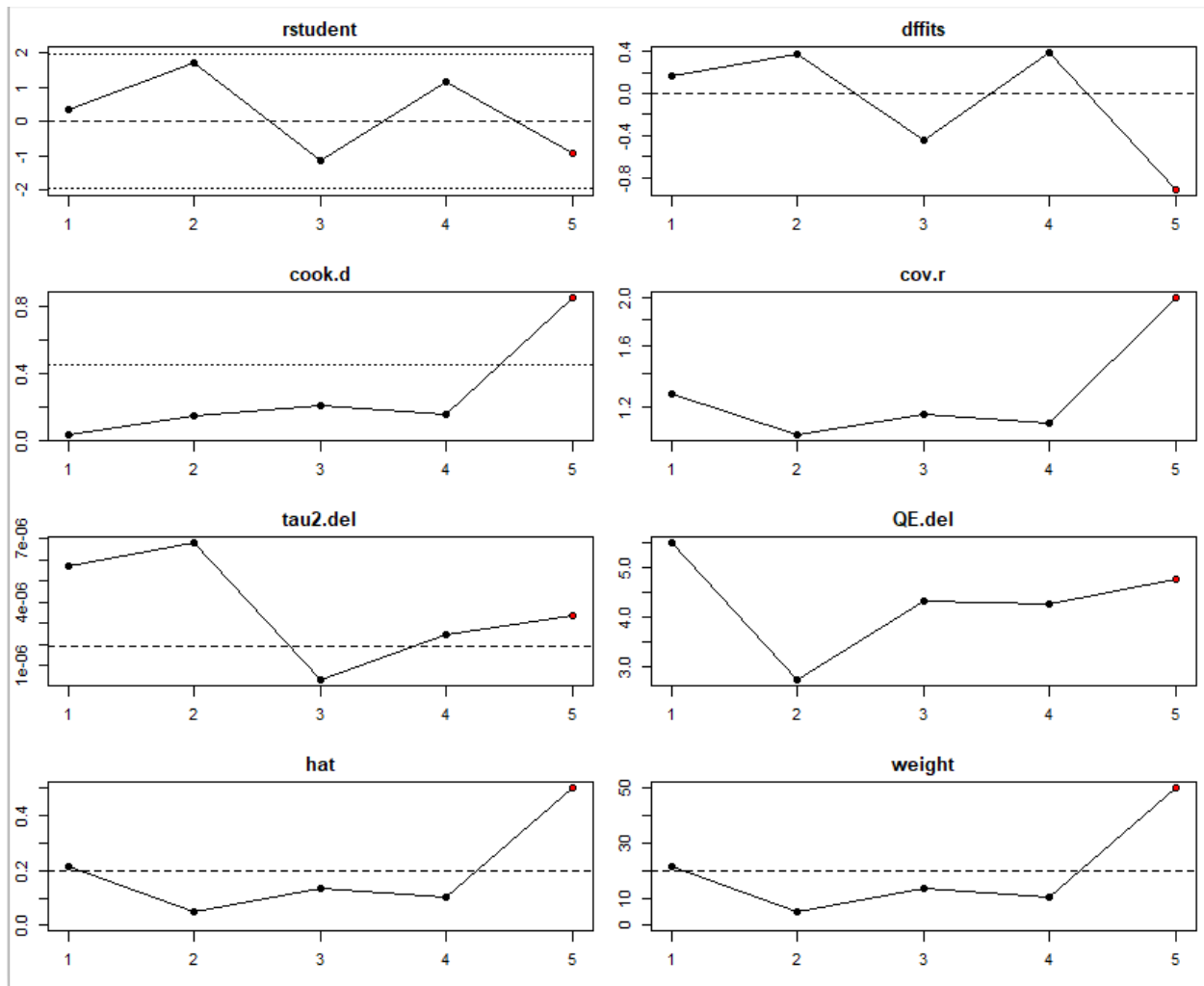


Figure 3.3. BMIz diagnose outlier plot

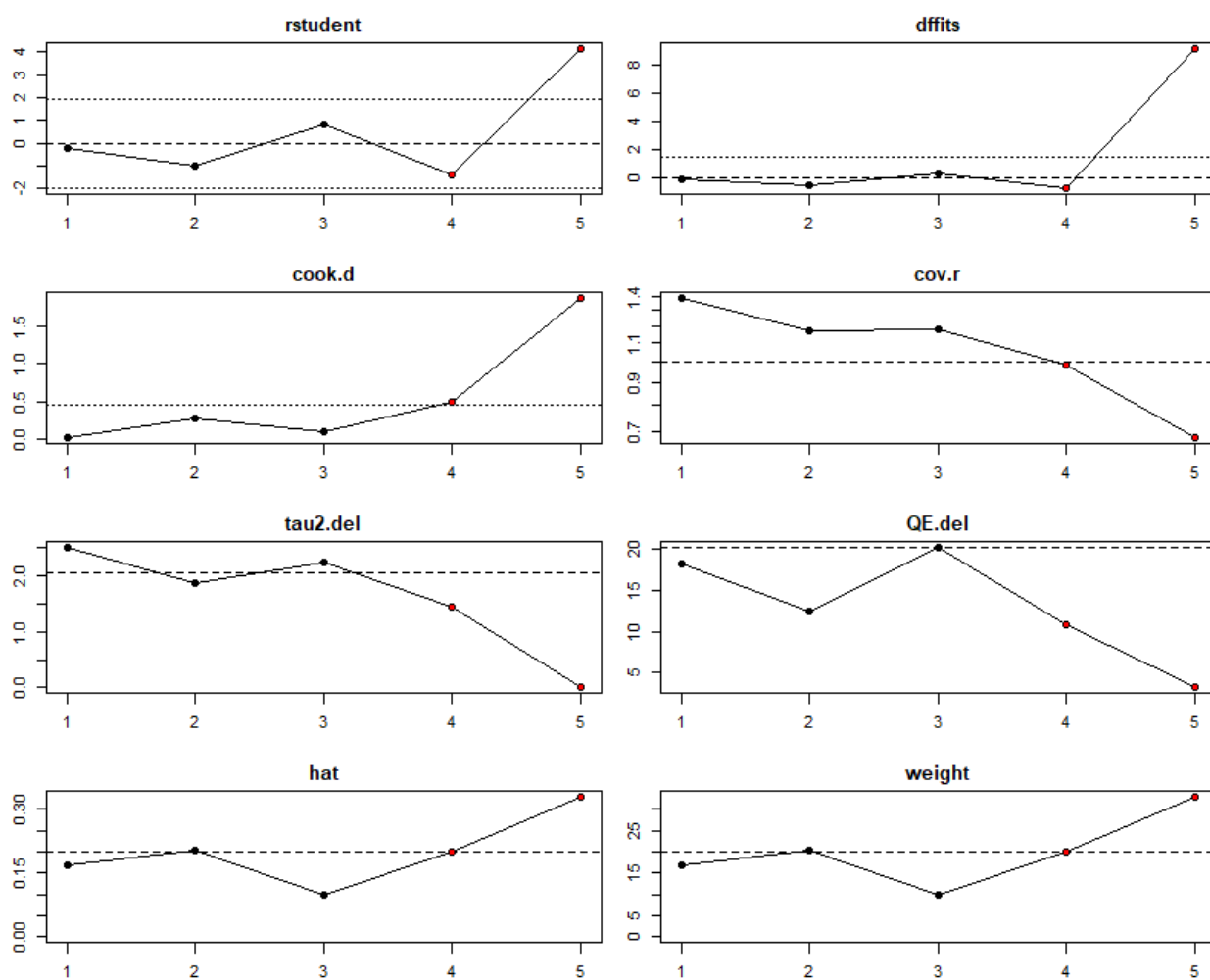


Figure 3.4. WC diagnose outlier plot

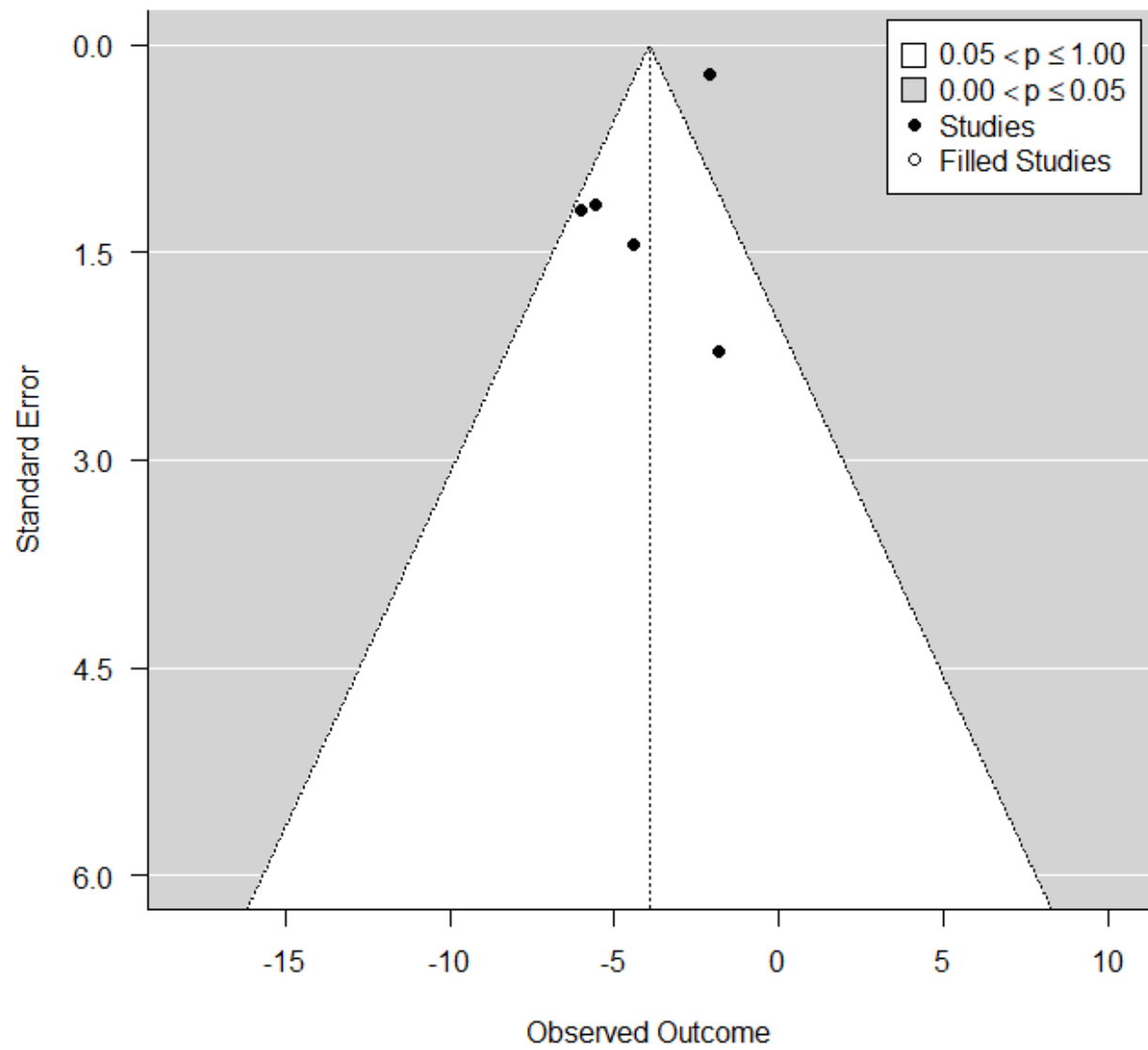


Figure 3.5. Bias diagnostic outlier plot

CHAPTER IV

PSYCHOLOGICAL NEED-SUPPORT CENTERED LIFESTYLE PROGRAM TO TREAT PEDIATRIC OVERWEIGHT AND OBESITY AMONG HISPANIC ADOLESCENTS: A RANDOMIZED CONTROLLED TRIAL

¹Deng, Y & Yli-Piipari, S. To be submit to Medicine & Science in Sports & Exercise

4.1 Abstract

Background: Obesity disproportionately affects racial-ethnic minorities. Hispanic youth have the highest obesity rate of all racial/ethnic groups in the U.S. (28%). Considering the high prevalence of obesity in the Hispanic population and the evidence that suggests that Hispanic adolescents have fewer opportunities to participate in weight loss interventions, efforts to design effective weight loss programs for this population are well warranted. Based on research on the best practices to treat pediatric obesity, we designed and tested the BRAVO! lifestyle program, consisting of exercise, nutrition education, and positive psychology-centered behavior modification, to create sustainable change in Hispanic communities. Objective: The purpose of this study was to examine the efficacy of the psychological need-support centered BRAVO! program lifestyle on the 12-week and longer-term changes in participants' body composition (body mass index [BMI], standardized BMI [BMIZ], waist circumference [WC]), and health-related fitness (cardiovascular endurance, and muscular strength/endurance). The second aim of this study was to explore the changes in participants' physical activity (PA) and psychological outcomes during the intervention. Methods: This study was a randomized controlled trial with a sample of 40 pediatrician-referred participants ($M_{age} = 13.20 \pm 1.54$) allocated to two parallel arms: 1) BRAVO! ($n = 20$) and b) "usual care" control group ($n = 20$). The 12-week BRAVO! consisted of 24 exercise sessions (twice/week, 60min/session) focusing on cardiovascular endurance and muscular strength and endurance and family-based nutrition classes (once/week, 30min/session) focusing on healthy cooking and eating. Behavior modification strategies were based on the self-determination theory focusing on supporting participants' psychological needs. Eight specific strategies to harness participants' psychological needs were applied such as

providing meaningful rationale and choice. Results: The results showed that the BRAVO! was efficacious in generating positive changes in participants' BMI ($F[1, 31] = 23.83, p < .001, \eta^2 = .45$), WC ($F[1, 31] = 26.58, p < .001, \eta^2 = .48$), cardiovascular endurance ($F[1, 31] = 8.18, p = .008, \eta^2 = .23$), upper body muscular strength/endurance ($F[1, 31] = 28.33, p < .001, \eta^2 = .50$), and abdominal muscular strength/endurance ($F[1, 31] = 28.34, p < .001, \eta^2 = .45$). The changes in cardiovascular endurance vanished but the changes in BMI, WC, upper body muscular strength/endurance, and abdominal muscular strength/endurance remained for a longer, 6-week term. Conclusions: BRAVO!, a psychological need-support centered lifestyle program, was effective in improving at-risk Hispanic children's body composition and health-related fitness, as well as behavioral and psychological outcomes in the short and longer term.

Keywords: Adiposity, weight loss, intervention, body mass index, body composition, fitness

4.2 Introduction

Pediatric obesity is a public health concern that is associated with an increased risk of chronic diseases such as type 2 diabetes mellitus, metabolic syndrome, and cardiovascular diseases (Abdullah, Peeters, Courten, & Stoelwinder, 2010; Cardel, Atkinson, Taveras, Holm, & Kelly, 2020; Djalalinia, Qorbani, Peykari, & Kelishadi, 2015). In recent decades, the prevalence of obesity has increased not only in racial-ethnic minorities but also in low-income families (Jiwani et al., 2019; Jones-Smith, Dieckmann, Gottlieb, Chow, & Fernald, 2014; Min, Goodale, Xue, Brey, & Wang, 2021). According to the most recent data reported by the Centers for Disease Control Prevention (CDC; 2017-2018), Mexican American and Hispanic children and adolescents (i.e., 2-19-year-olds) have the highest obesity rate (e.g., 26.9% and 25.6%) of all racial/ethnic groups (Fryar, Carroll, & Ogden, 2018). In particular, Hispanic adolescents (12-19-year-olds) are becoming one of the fastest-growing pediatric obesity populations (Ogden et al., 2020). Thus, there is an essential need to design and implement effective treatments to target Hispanic adolescents and reduce health disparities.

Adolescence is a complex life stage as adequate nutrition and physical activity (PA) are vital for adolescents' growth, but poor diet quality, overeating problems, and low levels of regular PA may lead to overweight, obesity, and other chronic diseases (Lassi, Moin, Das, Salam, & Bhutta, 2017). Due to the multifactorial etiologies underlying the etiology of obesity embedded with the biobehavioral factors and cultural and socioeconomic disparities, solutions to treat pediatric obesity are extremely challenging. Lifestyle interventions consisting of a combination of exercise, nutrition education, and behavior modification/therapies are commonly recommended as a non-invasive strategy to treat pediatric obesity (Psaltopoulou et al., 2019;

Reinehr, 2013; Styne et al., 2017). In fact, evidence suggests that compared to a single intervention approach, combined exercise and diet interventions have a better efficacy in treating overweight and obesity in children and adolescents (Brown et al., 2016; Ho et al., 2013). Several meta-analyses have reported that lifestyle interventions can be efficacious in improving children and adolescents' weight status, body mass index (BMI), waist circumference (WC), and reducing numerous metabolic risk factors, e.g., low-density lipoprotein and fasting insulin (Berge & Everts, 2011; Deng et al., in review; Ho et al., 2012; Luckner, Moss, & Gericke 2012; Peirson et al., 2015; Salam et al., 2020; Stoner et al., 2016). When focusing on BMI, published meta-analyses have shown pediatric lifestyle interventions to be efficacious, with the effects ranging from -0.09 kg/m^2 (95% CI $[-.16, -.03]$; Luckner, Moss, & Gericke, 2012) to -2.00 kg/m^2 (95% CI $[-1.5, -2.5]$; Stoner et al., 2016; Table 4.1). In addition, Stoner et al. (2016) found lifestyle interventions to be effective in reducing participants' WC with an average effect being around -3.00 cm (95% CI $[-4.8, -1.30]$). A recent meta-analysis by this research team behind this experimental study (Deng et al., in review) examined the efficacy of randomized controlled pediatric lifestyle interventions, which included exercise, nutrition education, and/or motivation-centered behavior modification strategies to treat overweight and obesity among 11- to 17-year-old children and adolescents. Our meta-analysis showed that lifestyle interventions were moderately effective in impacting positive changes in participants' BMI (-1.77 kg/m^2 , 95% CI $[-2.65, -.88]$), BMI-z ($-.30$, 95% CI $[-.44, -.17]$), and WC (-3.72 cm , 95% CI $[-5.59, -1.85]$).

Although previous pediatric lifestyle interventions have largely focused on weight-related study outcomes, recent evidence suggests that childhood interventions should have a broader approach target not only weight, but also aim to improve children's cardiovascular and

muscle health (Mayr, Cohen, Isenring, Soenen, & Marshall, 2020). A few meta-analytic reviews have been published to summarize the effectiveness of exercise training on children's cardiovascular and muscular health (Joschtel et al., 2018; Lesinski, Herz, Schmelcher, & Granacher, 2020; Moncada-Jiménez & Carazo-Vargas, 2015; Payne, Morrow Jr, Johnson, & Dalton, 1997; Yang, Qiu, & Luo, 2021). For instance, Joschtel et al. (2018; $k = 24$) showed exercise training yielded large significant effects on cardiovascular fitness (oxygen consumption, $\text{VO}_2 \text{ max}$) (standard mean difference (SMD) = 1.16, 95% CI [.61, 1.70]). Yang, Qiu, and Luo (2021; $k = 12$) showed that resistance training can improve participants' $\text{VO}_2 \text{ max}$ (SMD = 5.83, 95% CI [3.52, 8.13], $p < .001$) and muscle strength (SMD = 2.18, 95% CI [.79, 3.56], $p = .002$), but no significant effect on muscle endurance (SMD = 10.00, 95% CI [-.22, 20.22], $p = .06$) was detected. These findings of Yang, Qiu, and Luo (2021) corroborated the findings of Lesinski, Herz, Schmelcher, and Granacher (2020; $k = 11$), which found resistance training to result in medium-to-large effects on muscle strength ($.54 \leq \text{SMD} \leq 1.12$) and small-to-large effects on muscle power ($.41 \leq \text{SMD} \leq .80$).

In addition to the changes in body composition and health-related fitness, research has shown pediatric lifestyle interventions to be effective in improving behavioral outcomes, e.g., PA behaviors, self-determined motivation, and well-being (Berge & Everts, 2011; Ho et al., 2012; Manninen et al., 2022). Several meta-analyses have summarized the effectiveness of lifestyle intervention on children's PA behaviors (Metcalf, Henley, & Wilkin, 2012; Brown et al., 2016), demonstrating small effects on PA (total) (SMD = .12, 95% CI [.04, .20], $p = .01$; Metcalf, Henley & Wilkin, 2012) and moderate-to-vigorous PA (SMD = .29, 95% CI [.14, .45], $p < .001$; Brown et al., 2016).

Although previous research has shown that pediatric lifestyle interventions are moderately efficacious in improving BMI and WC in overweight and obese child populations (Berge & Everts, 2011; Deng et al., in review; Ho et al., 2012; Luckner, Moss, & Gericke, 2012; Peirson et al., 2015; Salam et al., 2020; Stoner et al., 2016), and exercise interventions are effective in improving children's cardiovascular fitness and muscular strength/endurance (Joschtel et al., 2018; Lesinski, Herz, Schmelcher, & Granacher, 2020; Moncada-Jiménez & Carazo-Vargas, 2015; Yang, Qiu, & Luo, 2021), there are gaps in the knowledge base warranting this study.

First, considerable heterogeneity in the efficacy of the lifestyle interventions can be attributed to the numerous different methodological approaches. For example, a large portion of the reviewed lifestyle interventions did not offer actual exercise training, but exercise/PA recommendations and education. This likely contributes to the large effect size heterogeneity, as previous meta-analyses have shown that actual exercise, not the recommendation, is an important factor impacting the effectiveness of pediatric obesity interventions (Conelly, Duaso, & Butler, 2007; Deng et al., in review). Similarly, there has been great variability in previously conducted pediatric lifestyle interventions in regards to the intervention length, frequency, and content; which all can contribute to heterogeneity. Second, it is well known that diverse ethnic and cultural minority populations experience higher pediatric obesity prevalence rates and show higher vulnerability in early life behavioral risk factors (Dixon, Peña, & Taveras, 2012; Hardy, Jin, Mahrshahi, & Ding, 2019). Despite being the largest and fastest-growing minority group in the US (Pew Research Center, 2019), Hispanic adolescents, in particular, have been shown to have fewer opportunities to participate in behavioral interventions (Perez et al., 2013; Haughton

et al., 2018). In addition, underserved populations and particularly Hispanic participants oftentimes have poorer obesity program adherence compared to the general population (Isasi, Rastogi, & Molina, 2016; Moroshko, Brennan, & O'Brien, 2011; Tovar et al., 2014). Thus, tailored obesity treatment strategies are needed to accommodate better the needs of different ethnicities and to improve program reach and adherence (Moroshko, Brennan, & O'Brien, 2011). Finally, recent advances in positive psychology research centered around the self-determination theory have shown that program adherence and long-term behavior change can be improved by designing programs harnessing participants' psychological needs (Deci & Ryan, 1985, 2000; Manninen et al., 2022). Specifically, research indicates that if individuals' innate, psychological needs for autonomy (i.e., to experience growth and self-control), competence (i.e., to feel accomplished), and relatedness (i.e., to feel accepted by others and connected to the social environment) are met, it can lead to improved self-determined motivation, long-term goal adoption, and more successful goal-pursuit (Williams, Grow, Freedman, Ryan, & Deci, 1996). Programs that incorporate these psychological need-supportive strategies have been shown to be more effective due to better program adoption, engagement, and retention (Williams, McGregor, Zeldman, Freedman, & Deci, 2004).

Considering the aforementioned evidence of the efficacy of pediatric lifestyle interventions and the need to design psychosocial need-supportive lifestyle intervention programs to prevent and treat obesity in Hispanic communities, we designed a Bracing up Research on Adolescents' preVention of Obesity: BRAVO! (BRAVO!) lifestyle intervention program. This program collaborates with local pediatricians to help Hispanic families in their efforts to combat pediatric obesity in their communities. BRAVO! is a psychological need-

support centered program focusing on exercise, nutrition education, and psychological need-support centered behavior modification. The specific aim of this research was to examine the efficacy of the BRAVO! lifestyle intervention on the 12-week and longer-term changes in participants' body composition (BMI, BMIz, WC) and health-related fitness (cardiovascular endurance, and muscular strength/endurance). The second aim of this study was to explore the changes in participants' PA and psychological outcomes during and after the intervention.

4.3 Methods

4.3.1 Research Design

This study was a randomized controlled study with participants allocated into two arms: a) BRAVO! experimental and b) “usual care”. Cohort one began in 2021 (baseline: end of August, posttest: early December, and follow-up: end of January), and cohort two started in 2022 (baseline: early of January, posttest: mid-April, and follow-up: early May).

4.3.2 Participants

In total, 87 potential participants were referred by local pediatricians to participate in BRAVO!, with 40 participants ($M_{age} = 13.20 \pm 1.54$) signing all necessary paperwork and completing the baseline assessment. Figure 4.1 illustrates the flow of the participants. Institutional Review Board permission approval was obtained before any research activities. All participants and their parents consented to participate in this study.

4.3.3 Intervention

BRAVO! is a 12-week intervention including a) moderate-to-vigorous intensity exercise training (twice/week, 60min/session) focusing on cardiovascular endurance and muscle strength/endurance, b) family-based nutrition education (once a week, 30min/session) focusing on healthy

nutrition and eating, and (c) self-determination theory-centered behavior modification. The total intended dose of the intervention was 24hrs of exercise and 6hrs of nutrition education.

The contents of exercise and nutrition lessons are listed in Table 4.2.

4.3.3.1 Exercise

The exercise curriculum was delivered by trained exercise instructors. Each exercise lesson had an objective and a theme (e.g., martial arts, circuit training, boxing, yoga). Primary objectives of the exercise lessons focused on cardiovascular endurance (25%), lower body muscular strength and endurance (16.67%), core muscular strength and endurance (25%), upper body muscular strength and endurance (16.67%), and flexibility (16.67%). Each exercise session was designed to achieve at least one of the following benchmarks: (a) participant indicated exercise exertion as a five or six on the Borg Rating of Perceived Exertion Scale (10 range scale) and/or (b) heart rate > 64% of the child's estimated maximal heart rate after the main session activity.

4.3.3.2 Nutrition Education

The nutrition curriculum was delivered by trained instructors. The objective of nutrition education was to engage participants and their parents in nutrition education to improve participants' diet. The educational content of the sessions was guided by the 2015-2020 Dietary Guidelines for Americans (US Department of Health and Human Services. 2019). The topics of the nutrition lessons included e.g., basic food group information, increasing fruits and vegetable consumption, reducing consumption of sugary drinks, and avoiding trans fats. Parents were encouraged to participate in the nutrition classes.

4.3.3.3 Behavior Modification

This study was guided by positive psychology research centered around the self-determination theory (Deci & Ryan, 1985, 2000; Ryan & Deci, 2017). In the context of the BRAVO! program, the program implemented the need-supportive instructional practices listed on Table 4.3 to improve participants' exercise motivation and well-being (Manninen et al., 2022).

All participants were provided with a BRAVO! workbook, which included objectives for each exercise and nutrition lesson, visual presentations of the nutrition topics, class activities, homework, and space to add notes, training, or measurements data, e.g., heart rates and exercise results.

4.3.4 Control group

The control, “usual care” group received no intervention. Control group participants were able to continue their typical activities during the 12-week intervention and 6-week follow-up periods. Control group participants were required to inform the researchers if they started any new hobbies or physical activities that may compromise the research integrity.

4.3.5 Procedures

Pediatricians from the primary care centers sent the names list of potential participants to the BRAVO! research team. Research team representatives screened the potential participants over the phone. After the screening, participant families were sent a BRAVO! information package and an online consent document for signing up. Study participants were invited to visit a large, public University research laboratory six times during the research project. The first visit was scheduled 9-10 days prior to the intervention. Participants who did complete informed consents online were given the possibility to sign the consent paperwork during their first visit. After the

necessary paperwork was completed, participants were given a wrist-worn accelerometer and instructions to wear the device for seven consecutive days. During the second visit to the laboratory (1-2 days prior to the beginning of the intervention), participants and their parents were asked to complete a self-report questionnaire, followed by a measurement of participants' waist, weight, and height. After the anthropometric measurements were taken, participants were asked to complete fitness tests (first the Progressive Aerobic Cumulative Endurance Run [PACER] test followed by push-up and curl-up tests). In addition, participants were asked to return their accelerometers. The Third laboratory visit was scheduled for two to four days after the intervention. The procedures were similar to the second visit with the exception that during the third visit accelerators were again given to the participants and they were asked to wear them for seven consecutive days. The Fourth visit occurred approximately one week later in order to drop off their accelerometers (9-11 days after the intervention). The Fifth participant visit was identical to the second visit. Finally, during the sixth visit participants were dropping off their accelerometers for the final time, and participants were given \$30 for their efforts.

4.3.6 Primary Outcomes

4.3.6.1 Anthropometric measurements. Height and weight were measured to the nearest 0.1cm and .1kg using a portable stadiometer (SECA 213; SECA North America, Chino, California). Participants removed shoes and jackets before height and weight measurements. WC was measured to the nearest .1 cm at the level of umbilicus using a Gulick II flexible tape measure (Baseline Measurement Tape, US). Participants' height and weight were measured by a trained member of the research team. BMI was calculated using the standard formula of weight/height². For descriptive purposes to portray the prevalence of overweight and obesity, the age- and sex-

specific CDC cut-off points were utilized (<https://www.cdc.gov/obesity/basics/childhood-defining.html>).

4.3.6.2 Cardiovascular Endurance. Cardiovascular endurance was measured using the PACER test (Plowman & Meredith, 2013). Adhering to the cadence with an increasing pace, participants were asked to run as many 20-meter laps as possible. The PACER test has been shown to be a reliable and valid test to measure cardiorespiratory endurance in adolescents across different cultures (Olds, Tomkinson, Léger, & Cazorla, 2006).

4.3.6.3 Upper Body Muscular Endurance and Strength. A push-up test was used to measure participants' upper body muscular endurance and strength. The final score of the push-up test was the number of correctly completed push-ups. Push-up tests have been found to be valid measures to assess upper body muscular endurance and strength during adolescence (Plowman & Meredith, 2013).

4.3.6.4 Abdominal Muscle Endurance. The curl-up test was used to measure participants' abdominal muscular endurance and strength. In a starting position, participants were asked to lay on their backs with knees bent at 90 degrees, both feet on the floor, with arms straight and parallel to the body. An 11.4 cm wide measuring tape was situated under participants' legs so that their fingertips were just resting on the nearest edge of the tape. Participants were asked to curl up so that their fingers slid across the measuring tape until their fingertips reached the other side of the tape. The final score was the number of correctly completed curl-ups. This abdominal test has been found to be a reliable and valid test for abdominal strength and endurance (Plowman & Meredith, 2013).

4.3.7 Exploratory Outcomes

4.3.7.1 Physical Activity. Participants' PA behavior was measured objectively using the ActiGraph GT9X+ Link wrist-worn accelerometers (ActiGraph, Pensacola, FL). Participants were asked to wear the monitors on the non-dominant wrist, and the research team provided detailed verbal and written instructions on how to wear the monitors. The accelerometers were worn for seven consecutive days. Participants were asked to wear the devices all the time during their waking hours except during water-based activities, e.g., swimming and bathing. Data from participants with ≥ 500 recorded min/d for 4 days were included. A raw acceleration frequency of 30Hz was used, and the data were converted into 15s epoch counts. Data were analyzed using Actilife software version 6 software (ActiGraph LLC, Pensacola, FL, USA). Evenson's cut-points were used to calculate moderate to vigorous PA ($MVPA \geq 2296$ counts per minute) (Evenson, Catellier, D. J., Gill, Ondrak, & McMurray, 2008).

4.3.7.2 Self-Determined Motivation. Exercise motivation was assessed using the Behavioral Regulation in Exercise Questionnaire (BREQ-3, Markland & Tobin, 2004). The scale includes 24 items with four items per dimension of intrinsic motivation, integrated, identified, introjected, extrinsic regulation, and amotivation. The stem ("Why do you exercise?") was introduced, and participants responded to each item on a 5-point Likert scale ranging from 1 (not true for me) to 5 (very true for me). The questionnaire has been shown to have good validity and reliability (Markland & Tobin, 2004). In this study, internal consistencies of the scales at pre- and posttests, and follow-up tests were for amotivation .78, .83, and .75, for external regulation .70, .70, and .77, for introjected regulation .78, .83, and .69, for identified regulation (one item removed) .70, .75, and .70, and for intrinsic motivation .80, .93, and .75.

4.3.7.3 Psychological Well-Being. Psychological well-being was measured by the Satisfaction with Life Scale Children (SWLS-C; Diener et al., 1985). On the SWLS-C, respondents are asked to respond to five statements (e.g., “In most ways my life is close to the way I would want it to be”) on a 5-point Likert-type scale ranging from “strongly disagree” (1) to “strongly agree” (5). The total scale score can therefore range from five to 25. The validity of this scale has been shown to be acceptable (Gadermann et al., 2010). Internal consistency of this scale was .93, .95, and .95, baseline, posttest, and follow-up, respectively.

4.3.8 Fidelity Outcomes

4.3.8.1 Attendance. Attendance for both exercise and nutrition sessions was recorded by the instructors. Late arrivals and early departures were written down in the electronic data book.

4.3.8.2 Exercise Exertion. Heart rate monitors and Borg’s Rating of Perceived Exertion Scale (Borg, 1998) were used to monitor the objective and subjective exercise exertion. Specifically, average heart rate during the training sessions was assessed with Polar M400 heart rate monitors (Polar USA, Bethpage, New York). Participants’ perceived exercise exertion was assessed using the 10-point version of the Borg Rating of Perceived Exertion Scale (ranged from 1 = “very easy and light intensity” to 10 = “extreme fatigue”) (Borg, 1998). The specific measures were performed immediately after the warm-up and main activity.

4.3.8.3 Dietary behaviors. Participants were asked to complete the National Cancer Institute’s Automated Self-Administered 24-hour Dietary Recall (ASA24-2012 Bethesda, MD; Subar et al., 2012) to calculate 3-day (2 weekdays and 1 weekend day) trans-fat, sugar, and added-sugar intake. The ASA24 has been found to be a valid and reliable assessment method in this population (Hughes et al., 2017).

4.3.9 Statistical analyses

Statistical analyses were performed using the following procedures. Preliminary analyses were performed for missing data, outlier, normality, descriptive statistics, and Cronbach's alphas for internal consistency. The primary analysis used separate paired samples Bonferroni-corrected (Bonferroni corrected p -value) t -test analyses to test the within-group differences in the variables of interest. To test the between-group differences, separate, fixed-effect analyses of covariances (ANCOVA) were conducted across the time points to test the interaction between group (intervention vs. control) and the changes from baseline- to post-tests and the changes from the baseline to follow-up tests. In each analysis, a time, group, and a group-by-time interaction were entered as the independent variables, and a group-by-time interaction was interpreted. The assumptions for the ANCOVA, including normality, homogeneity of variance, covariance, and sphericity were analyzed. To compare the effect of the intervention in regards to the exploratory outcomes (e.g., dietary and physical activity behaviors, self-determined motivation, and subjective well-being), a two-way analysis of variance was conducted. Partial eta squared (η^2) was used to measure effect sizes (i.e., small $\leq .01$, $.01 > \text{medium} \leq .09$, and large $> .25$) for between-group differences. In the analyses of the secondary outcomes, univariable comparisons of study characteristics at baseline were conducted with t -tests.

4.3.11 Randomization Plan

Participants were randomly assigned to two different groups (e.g., BRAVO or control group) by block randomization procedure (Kang, Ragan, & Park, 2008). This method is designed to randomize participants into groups that result in equal sample sizes. In this study, possible balanced combinations with 2C (control) and 2T (treatment) blocks are randomly chosen to

determine the assignment of all 40 participants. This procedure resulted in 20 participants in both the control and treatment groups

4.3.10 Sample size estimate

Statistical power was calculated for the ANCOVA using G*Power 3.1.2. (Faul, Erdfelder, Lang, & Buchner, 2007). For the body composition variables, power was determined based on the reported effect sizes ranging between -.5 and -.47 (Ho et al., 2012;). For the cardiovascular endurance and muscle strength/endurance outcome variables, previous meta-analyses have shown the effects range between .47 and .55 (Janicke et al., 2014; Lesinski, Herz, Schmelcher, & Granacher, 2020). We conservatively estimated that the intervention would produce an effect size of .25. Using an alpha of .05, and effect size .25, we expected that a sample of 34 participants was required for 80% power.

4.4. Results

In total, 87 potential participants were referred to the BRAVO! by several local pediatricians, and 40 participants ($M_{\text{age}} = 13.20 \pm 1.54$) completed the baseline assessment. The number of randomized participants who completed data collection visits at each time was as follows: 40 at the baseline, 32 at post-test (experimental = 12, control = 20), 32 at the follow-up (experimental = 12, control = 20). Retention over the 18 weeks was 80%. Five participants dropped out after the baseline test, three participants dropped out during the intervention (reported a lack of time). Table 4.4 illustrates the baseline characteristics of the participants. At the baseline, 25% of the intervention group participants were overweight and 75% obese. Overweight/obesity prevalence rates for the posttest and follow-up were 25%/75%, and 33.3%/67.7%, respectively. For the control group, the subsequent percentages were 40%/60%, 35%/65%, and 30%/70%.

4.4.1 Fidelity Outcomes

Exercise training adherence for the BRAVO! group was relatively high, with the average attendance rate being 88.5%. Participants' average heart rate was 128.33 ± 15.44 beats/min and subjective perceived exertion was 5.66 ± 1.40 . On average, participants met the intended a priori benchmarks. The highest average perceived exertion score (6.58 ± 1.88) was assessed during the Spelling game (lesson week 11, day 2), with 90% of the participants meeting the benchmark. The lowest average perceived exertion score (3.50 ± 1.60) was assessed during Yoga (lesson week 17, day 2), in which only 56% of the participants met the benchmark.

Nutrition lesson adherence for the BRAVO! group was 85%, but parents' attendance rate for the nutrition lessons was only 56%. Study findings suggested some changes in participants' diets as there was a declining trend in consuming added sugar ($M_{baseline} = 17.34 \pm 3.93$ g/d; $M_{post} = 13.50 \pm 2.10$ g/d; $t[11] = -4.01$, $p = .002$, $d = 1.17$) and general sugar ($M_{baseline} = 91.12 \pm 24.50$ g/d; $M_{post} = 81.41 \pm 19.86$ g/d; $t[11] = -3.18$, $p = .009$, $d = .91$). However, there was no statistically significant changes in trans-fat consumption.

4.4.2 Primary Outcomes

4.4.2.1 Within-Group Changes

4.4.2.1.1 Body Composition

Table 4.5 shows the descriptive data on the study variables. To examine the differences between baseline- and post-test results, paired sample *t*-test analyses were conducted separately for the experimental and control groups. Within-group analyses for the intervention group showed that there was a statistically significant baseline-post change ($M_{baseline} = 35.09 \pm 5.45$; $M_{post} = 33.51 \pm 6.09$; $t[11] = -3.14$, $p = .009$, $d = .91$) and longer-term change ($M_{baseline} = 35.09 \pm 5.45$; $M_{follow-up}$

= 33.37 ± 6.49 ; $t[11] = -2.52$, $p = .028$, $d = .73$) in BMI and WC ($M_{baseline} = 102.04 \pm 15.06$; $M_{post} = 99.17 \pm 14.71$; $t[11] = -3.30$, $p = .007$, $d = .95$; $M_{baseline} = 102.04 \pm 15.06$; $M_{follow-up} = 98.62 \pm 13.35$; $t[11] = -2.62$, $p = .024$, $d = .75$). There was a significant baseline-post increase in BMI of the control group ($M_{baseline} = 30.84 \pm 3.30$; $M_{post} = 31.84 \pm 4.09$; $t[19] = 3.03$, $p = .007$, $d = .68$) as well as WC ($M_{baseline} = 99.02 \pm 8.33$; $M_{post} = 100.41 \pm 9.22$; $t[19] = 3.30$, $p = .004$, $d = .74$). In addition, similar longer-term changes in the control group's BMI ($M_{baseline} = 30.84 \pm 3.30$; $M_{follow-up} = 32.67 \pm 4.10$; $t[19] = 3.03$, $p = .007$, $d = 1.07$) and WC ($M_{baseline} = 99.02 \pm 8.33$; $M_{follow-up} = 102.25 \pm 10.21$; $t[19] = 5.04$, $p < .001$, $d = 1.13$) was detected. There were no statistically significant changes in BMIz in either the BRAVO! or control groups.

4.4.2.1.2 Cardiovascular fitness

During the intervention, participants' abdominal muscular endurance/strength ($M_{baseline} = 15.14 \pm 10.84$; $M_{post} = 17.74 \pm 12.89$; $t[19] = -3.29$, $p = .008$, $d = .94$) and upper body muscular endurance/strength ($M_{baseline} = 6.33 \pm 4.15$; $M_{post} = 7.51 \pm 4.15$; $t[19] = -3.11$, $p = .011$, $d = .99$) improved. However, there were no statistically significant changes in cardiovascular endurance (neither short nor longer term) or longer-term changes in abdominal or upper body muscular strength/endurance. In addition, the results demonstrated a statistically significant decline in the control group participants' short ($M_{baseline} = 10.00 \pm 4.54$; $M_{post} = 9.20 \pm 2.80$; $t[19] = -3.45$, $p = .003$, $d = .77$) and longer-term ($M_{baseline} = 10.00 \pm 4.54$; $M_{post} = 7.55 \pm 3.30$; $t[19] = 3.30$, $p < .001$, $d = 1.00$) cardiovascular endurance. In addition, there were statistically significant decreases in participants' abdominal muscular endurance and strength and upper body muscular endurance and strength over both the short and longer term.

4.4.2.2 Between-Group Changes

4.4.2.2.1 Baseline-Post-test Changes

One-way ANCOVAs were conducted to compare the effectiveness of the BRAVO! program on participants' body composition and health-related fitness variables. Levene's test and normality checks were conducted prior to the ANCOVAs to test the normality and homogeneity assumptions. Results revealed a significant between-group intervention effect on BMI ($F[1, 31] = 23.83, p < .001, \eta^2 = .45$), and WC ($F[1, 31] = 26.58, p < .001, \eta^2 = .48$). The changes can be observed in Figure 4.2 and Figure 4.3. In addition, there was a significant between-group intervention effect on cardiovascular endurance ($F[1, 31] = 8.18, p = .008, \eta^2 = .23$), upper body muscular strength/endurance ($F[1, 31] = 28.33, p < .001, \eta^2 = .50$), and abdominal muscular strength/endurance ($F[1, 31] = 28.34, p < .001, \eta^2 = .45$). However, there was no statistically significant between-group effect on BMIz ($F[1, 31] = 2.14, p = .154$).

4.4.2.2.2 Longer-Term Changes

One-way ANCOVAs for the longer-term changes showed that there was a longer-term significant between-group effect on BMI ($F[1, 31] = 26.58, p < .001, \eta^2 = .48$), WC ($F[1, 31] = 24.32, p < .001, \eta^2 = .46$), upper body muscular strength/endurance ($F[1, 31] = 10.78, p < .001, \eta^2 = .28$), and abdominal muscular strength/endurance ($F[1, 31] = 5.08, p = .032, \eta^2 = .15$). However, there were no statistically significant differences in BMIz ($F[1, 31] = 1.26, p = .271$) or cardiovascular endurance ($F[1, 31] = 2.60, p = .118$).

4.4.3 Exploratory outcomes

4.4.3.1 Within-Group Changes

4.4.3.1.1 Physical Activity Within-group analyses for the intervention group showed that there was a statistically significant decline in light PA (LPA; $M_{baseline} = 440.94 \pm 30.90$; $M_{post} = 335.17 \pm 29.42$; $t[19] = -3.38$, $p = .006$, $d = .97$), but there was no change in MVPA or steps. Results showed, however, that there was a statistically significant decline in the control group participants' MVPA ($M_{baseline} = 175.48 \pm 79.70$; $M_{post} = 159.48 \pm 70.97$; $t[19] = -2.80$, $p = .011$, $d = .63$) and steps ($M_{baseline} = 8,208.08 \pm 2,519.03$; $M_{post} = 7,426.76 \pm 2,618.21$; $t[19] = -2.49$, $p = .034$, $d = .83$), but there were no changes in LPA.

4.4.3.1.2 Motivation Regulations

On the motivational regulations, paired samples *t*-tests showed no statistically significant changes for the intervention group. These findings were detected across 12- and 18-weeks. However, there was a statistically significant change for the control group in intrinsic motivation ($M_{baseline} = 2.17 \pm .68$; $M_{post} = 1.85 \pm .67$; $t[19] = -5.94$, $p < .001$), integrated motivation ($M_{baseline} = 2.49 \pm .52$; $M_{post} = 2.35 \pm .53$; $t[19] = -2.34$, $p = .030$), introjected regulation ($M_{baseline} = 3.11 \pm .64$; $M_{post} = 3.28 \pm .68$; $t[19] = 2.40$, $p = .027$), extrinsic regulation ($M_{baseline} = 3.33 \pm .65$; $M_{post} = 3.65 \pm .60$; $t[19] = 4.95$, $p < .001$), amotivation ($M_{baseline} = 2.89 \pm 0.63$; $M_{post} = 3.13 \pm .71$; $t[19] = -3.82$, $p = .001$) but not statistically change in identified regulation ($M_{baseline} = 2.69 \pm .14$; $M_{post} = 2.58 \pm .16$; $t[19] = -1.76$, $p = .095$). Overall, these findings indicate that the quality of motivation worsened for the control group participants.

4.4.3.1.3 Psychological Well-being

Finally, results showed that the experimental group participants' psychological well-being improved ($M_{baseline} = 3.32 \pm 1.20$; $M_{post} = 3.64 \pm 1.08$; $t[4] = 4.00$, $p = .016$, $d = .98$), but there were no longer-term statistically significant changes ($M_{baseline} = 3.58 \pm 1.15$; $M_{follow-up} = 3.47 \pm$

.88; $t[11] = -.67, p = .514, d = .98$). For the control group, the results showed a statistically significant baseline- to post-test decline in psychological well-being ($M_{baseline} = 1.92 \pm .83$; $M_{post} = 1.63 \pm .74$; $t[11] = -4.65, p < .001, d = 1.03$) as well as a longer-term decline ($M_{baseline} = 1.92 \pm .83$; $M_{follow-up} = 1.48 \pm .62$; $t[11] = -4.59, p < .001, d = 1.02$).

4.4.3.2 Between Group Changes

4.4.3.2.1 Physical Activity

We found a significant between-group effect in short term LPA ($F[1, 31] = 17.68, p < .001, \eta^2 = .38$), but there were no statistically significant between-group effects on moderate PA(MPA) ($F[1, 31] = 1.01, p = .322$), MVPA ($F[1, 31] = .42, p = .521$), vigorous PA (VPA) ($F[1, 31] = .550, p = .464$), or steps ($F[1, 31] = 4.06, p = .053$). However, for the long-term changes, we found a statistically significant between-group effects in LPA ($F[1, 31] = 8.71, p = .006, \eta^2 = .24$), but there were no significant between-group effects in MPA ($F[1, 31] = 2.20, p = .149$), MVPA ($F[1, 31] = .37, p = .546$), or steps ($F[1, 31] = .35, p = .558$).

4.4.3.2.2 Motivational Regulations

The study found a significant between-group baseline-posttest effect on intrinsic motivation ($F[1, 31] = 5.77, p = .023, \eta^2 = .17$) and extrinsic motivation ($F[1, 31] = 10.12, p = .003, \eta^2 = .26$). However, there was no statistically significant between-group effects on integrated regulation ($F[1, 31] = 2.63, p = .115$), identified regulation ($F[1, 31] = .11, p = .743$), introjected regulation ($F[1, 31] = 3.59, p = .068$), or amotivation ($F[1, 31] = 3.60, p = .068$). The study found a significant between-group effect on longer-term intrinsic motivation ($F[1, 31] = 9.81, p = .004, \eta^2 = .25$), and extrinsic regulation ($F[1, 31] = 11.89, p = .002, \eta^2 = .29$). However, there is no statistically significant between-group effects on integrated regulation ($F[1, 31] = 2.63, p =$

.115, $\eta^2 = .08$), identified regulation ($F[1, 31] = .05, p = .823$), introjected regulation ($F[1, 31] = 2.85, p = .102$), or amotivation ($F[1, 31] = 2.74, p = .109$).

4.4.3.2.3 Psychological Well-being

Results revealed a statistically significant between-group intervention effect on psychological well-being ($F[1, 31] = 33.82, p < .001, \eta^2 = .61$). In addition, results showed a similar, significant between-group intervention effect for longer-term well-being ($F[1, 31] = 24.73, p < .001, \eta^2 = .46$).

4.5 Discussion

The purpose of this study was two-fold. First, this study aimed to examine the efficacy of the psychological need-support centered BRAVO! lifestyle intervention program on the 12-week and longer-term changes in participants' body composition and health-related fitness. Second, this study aimed to explore the changes in participants' PA behaviors and psychological outcomes, e.g., self-determined motivation and psychological well-being. This study builds on the tenets of positive psychology research centered around the self-determination theory, which collectively posits that designing programs harnessing participants' psychological needs plays a key role in improving program adherence and long-term behavior change. Given the high prevalence of Hispanic youth with high program dropout rates and low program maintenance (Isasi, Rastogi, & Molina, 2016; Moroshko, Brennan, & O'Brien, 2011; Tovar et al., 2014), the finding of this research makes several meaningful contributions to obesity prevention, with a high potential for replication in underserved populations across the nation.

First, the results showed high attendance rates among the participants, with 88.5% and 85% attendance rates for exercise and nutrition education, respectively. High attendance rates in

this study suggest that BRAVO! maybe be a feasible intervention to improve Hispanic adolescents' program adherence rates, which have previously been shown to be low in the Hispanic population (Tovar et al., 2016). It is noteworthy that BRAVO! parents' nutrition education attendance rate was only 56%. It is commonly known that parents play a central role in shaping children and adolescents' lifestyles by influencing PA and food preferences. Research has shown that in weight loss interventions for overweight/obese youth, parents' involvement accounts for around 20% of the variance relating to their children's outcome success (Kitzmann et al., 2010). In other words, adolescents have been shown to achieve better weight loss outcomes when their parents received the intervention as well (Kitzmann et al., 2010). Thus, advocacy efforts have been taken to promote increased parental involvement to promote their children's health (Benton, 2004). In this study, we also assessed experimental group participants' dietary behaviors (sugar and fat consumption) to have an idea of whether participants implement any changes in their dietary behaviors. This study found a statistically significant decline in BRAVO! group's consumption of sugars and added sugars for the short and longer terms. Although there was a significant decrease in the BRAVO! group participants' sugar consumption, their average consumption of sugar clearly exceeded the national recommendations for healthy sugar, consumption being almost three-fold higher than the national recommendations. Although we did not find any statistically significant changes in trans-fat, these evidenced changes indicate that participants did some changes in their diet which is most likely due to their participation in the BRAVO! program.

Second, this study demonstrated positive within-group changes in the BRAVO! group. Our study showed that participants experienced an average 1.58 kg/m² (around 2.45 kg) decline

in their BMI and around 3.00 cm decrease in their WC. This reduced WC continued beyond the 12-week intervention throughout the 18 weeks. These results are promising and help to explain the results of the primary aims of this study derived from the between-group analyses. The control group experienced an average 1.83 kg/m² (around 4.81 kg) increase in their BMI and a 3.22cm increase in their WC across time. These preliminary findings suggest that BRAVO! lifestyle intervention can improve participants' weight status and reverse the negative health trend apparent in the control group. This positive trend tends to continue for a longer term as BRAVO! participant's BMI (.41 kg/m²) and WC (.55 cm) continued to decline, whereas the control group's BMI (.83 kg/m²) and WC (1.84 cm) continued to increase.

Primary findings of this study suggest that BRAVO! was efficacious in initiating a significant positive change in BMI (~1.5 kg/m² decline) and WC (~3.00 cm decline). These findings were consistent with the findings of the previous meta-analyses that have shown effects range from -2.00 kg/m² to -1.77 kg/m² (95% CI [-1.5, -2.5]) in BMI and -3.00 cm (95% CI [-4.8, -1.30]) in WC (Deng et al., in review; Stoner et al., 2016). Although BRAVO! program was specifically tailored to Hispanic adolescents, the effect sizes for the body composition were similar to the effect sizes of the previous meta-analyses. Maybe more importantly, BRAVO! showed satisfactory efficacy in initiating longer-term changes. Our study showed that BRAVO! participants had healthier BMI and WC after six weeks of the intervention. These findings are positive indicators that BRAVO! can help Hispanic overweight and obese adolescents to improve their body composition. Previous studies, however, have suggested that lifestyle interventions, especially during childhood, should focus on improving overall health-related fitness and focus less on body composition (Mayr et al., 2020; Friedemann, Heneghan, & Ward,

2015). Our findings showed that that BRAVO! was effective in improving participants' cardiovascular endurance, upper body muscular strength/endurance, and abdominal muscular strength/endurance. These findings corroborate the findings of previous studies that have shown that lifestyle interventions can improve adolescents' fitness (VO₂ max) (Joschtel et al., 2018; Patsopoulou et al., 2017; Yang, Qiu, & Luo, 2021). In addition, with the exception of cardiovascular endurance, our study showed clear improvements in participants' longer-term upper body and abdominal muscular endurance/strength.

These findings support the efficacy of BRAVO! intervention. Longer-term changes in body composition and health-related physical fitness are important as physical fitness and BMI has an inverse relationship (Brunet et al., 2007; Fogelholm et al., 2008). It is noteworthy that while the BRAVO! group body composition improved, the trend was totally opposite in the control group. Our results specifically showed a statistically significant increase in body composition and decline in health-related fitness for control group participants. The unhealthy trend is unfortunate and underscore the importance of comprehensive interventions that integrate health-related fitness to improve healthy weight status among Hispanic adolescents. In light of this perspective, our study suggests that future lifestyle intervention should include health-related fitness to improve at-risk Hispanic adolescents' overall healthy weight status.

In regards to our exploratory aim two, the mean level data suggests that BRAVO! group's PA increased and the control groups' PA decreased but these trends were not strong enough to be statistically significant. We found that there was a statistical difference in LPA, but there were no statistically significant MVPA or steps changes in either the short- or longer-term. Interestingly, our results suggested that none of the participants had any VPA in their weekly

schedule across the three-time points. These results in a lack of VPA are highly problematic as VPA is highly important for health, especially for youth's well-being e.g., muscle strength and cardiovascular function (Wittmeier, Mollard, & Kriellaars, 2008). In addition, previous research has found an association between VPA and cardiometabolic risk factors (Hay et al., 2012; Parikh, & Stratton, 2011; Owens, Galloway, & Gutin, 2017). The lack of VPA may be due to a lack of obese adolescents' participation in organized physical activities, e.g. intra- or extra-mural sport, which may narrow their opportunities for high-intensity PA. Previous research has found that overweight/obese youth tend to have a number of barriers, e.g., body consciousness, peer influences, and socioeconomic status (Zabinski et al., 2003), that makes their participation in organized sports and activities challenging (Deforche et al., 2005). Our study highlights the need for future lifestyle intervention research to incorporate effective strategies (e.g., improve enjoyment and other positive affective experiences) and reduce potential barriers to improve adolescences' daily regular PA (e.g., walking and free-play) and regular VPA (e.g., participating in recreational sports) to improve their health.

Lastly, it is noteworthy that BRAVO! was effective in improving intrinsic motivation and lowering extrinsic regulation as well as psychological well-being. Our within-group analyses showed that BRAVO! group's intrinsic motivation and well-being increased and external regulation decreased, while the control group's trend was inverse in both the short- and longer-term. Our between-group analyses found a significant between-group effect in short-term intrinsic motivation and extrinsic motivation. This is important as previous research has found intrinsic motivation as well as introjected and identified regulation to be linked with positive outcomes e.g., increased enjoyment (Rottensteiner, Happonen, & Kontinen, 2015), and reduced

drop-out intentions (Gillet, Berjot, Vallerand, & Amoura, 2012), and greater exercise participation (Pelletier, Fortier, Vallerand, & Briere, 2001). High extrinsic motivation, on the other hand, has been found to be associated with low program participation (Pelletier, Fortier, Vallerand, & Briere, 2001). BRAVO! participants experienced a positive motivational trend and improved psychological well-being, while control group participants' trend was negative. Considering the previous evidence and our findings, it is safe to say that an improved motivational profile partially contributed to the success of the BRAVO! It was encouraging that this positive trend for BRAVO! group participants' intrinsic motivation, extrinsic regulation, and psychological well-being continued beyond the BRAVO! intervention, as our analyses showed longer-term positive changes all the way to six weeks after the end of the BRAVO!

4.5.1 Strengths and limitations

Strengths of the study included a randomized controlled study design contributing to high internal validity. In addition, this study implemented strict fidelity measures to ensure that the intervention was delivered as intended. Secondly, this study utilized objective assessment strategies to measure PA and eating behaviors as well as exercise exertion. Third, the study utilized a broad range of outcomes measures to examine the efficacy of the BRAVO!.

Previously, the usage of BMI as an indicator of adolescents' health has been criticized for its validity (Okorodudu et al., 2010). Considering the importance of measuring adolescents' health more broadly, we included measures of health-related fitness, e.g., cardiovascular endurance and abdominal and upper body strength/endurance to better understand the impact of BRAVO! on Hispanic adolescents' health. Lastly, this study focused on adolescence, an important development stage for intervention. The findings of this study generate new scientific knowledge

about effective approaches for obesity treatment with a high potential for replication in ethnic minority populations across the nation.

Several limitations should not be neglected. First, although we had two cohorts of data collection, the total sample size for the intervention group was small. This study may be underpowered because our previous power analysis suggested 34 participants, however, only 32 participants completed three data collection phases. This may have led to the situation that this study was not able to detect some of the smaller-sized effects. A fully powered sample size is needed for the future research. In addition, the high drop-out rates (e.g., 34 %) in the intervention group may impact the outcomes of the findings, which may have led to groups with lower attrition achieving greater weight losses due to participants being more highly motivated than those who dropped out of the intervention. Future research needs to implicate strategies to improve program adherence and explore barriers, e.g., conflicting schedules, financial constraints. Third, the randomization for this study was not successful as BRAVO! group had higher baseline BMI compared to the control group participants. To overcome these issues, we chose to use ANCOVA over repeated measures analysis of variance to compare between-group covariance instead of mean level differences. Lastly, it is noted that this study was conducted during the COVID-19 pandemic. This may have impacted the BRAVO! sampling and attrition rates. In addition, previous research has shown COVID-19 to be harmful for young adults self-determined motivation by decreasing adaptive and increasing maladaptive motivation (Deng, Hwang, Kim, & Yli-Piipari, 2022).

4.6 Conclusion

In conclusion, the findings of this study are promising and suggest that this psychological need-support centered, 12-week long BRAVO! lifestyle program can be an effective strategy in improving overweight and obese Hispanic adolescents' metabolic and physiological health.

Based on this experiment, it can be concluded that BRAVO! can initiate longer-term changes in Hispanic overweight and obese adolescents' body composition, muscular endurance and fitness as well as intrinsic motivation and psychological well-being.

4.7 References

1. Abdullah, A., Peeters, A., de Courten, M., & Stoelwinder, J. (2010). The magnitude of association between overweight and obesity and the risk of diabetes: A meta-analysis of prospective cohort studies. *Diabetes Research and Clinical Practice*, 89(3), 309-319.
2. Benton, D. (2004). Role of parents in the determination of the food preferences of children and the development of obesity. *International Journal of Obesity*, 28(7), 858-869.
3. Berge, J. M., & Everts, J. C. (2011). Family-based interventions targeting childhood obesity: A meta-analysis. *Childhood Obesity*, 7(2), 110-121.
4. Borg, G. (1998). *Borg's perceived exertion and pain scales*. Human kinetics.
5. Brown, H. E., Atkin, A. J., Panter, J., Wong, G., Chinapaw, M. J., & Van Sluijs, E. M. F. (2016). Family-based interventions to increase physical activity in children: A systematic review, meta-analysis and realist synthesis. *Obesity Reviews*, 17(4), 345-360.
6. Brunet, M., Chaput, J. P., & Tremblay, A. (2007). The association between low physical fitness and high body mass index or waist circumference is increasing with age in children: the 'Quebec en Forme' Project. *International Journal of Obesity*, 31(4), 637-643.
7. Cardel, M. I., Atkinson, M. A., Taveras, E. M., Holm, J. C., & Kelly, A. S. (2020). Obesity treatment among adolescents: A review of current evidence and future directions. *JAMA Pediatrics*. 174(6), 609-617.
8. Connelly, J. B., Duaso, M. J., & Butler, G. (2007). A systematic review of controlled trials of interventions to prevent childhood obesity and overweight: A realistic synthesis of the evidence. *Public Health*, 121(7), 510-517.
9. Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum Press.
10. Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227-268.
11. Deforche, B., De Bourdeaudhuij, I., Tanghe, A., Deboode, P., Peter Hills, A., & Bouckaert, J. (2005). Role of physical activity and eating behaviour in weight control after treatment in severely obese children and adolescents. *Acta Paediatrica*, 94(4), 464-470.
12. Deng, Y., Hwang, Y., Kim, T., & Yli-Piipari, S. (2022). Changes in college students' body mass index, physical activity, and motivation before and during the COVID-19 third-wave lockdown. *International Journal of Kinesiology and Sport Science*, 10(2), 34-41.
13. Deng, Y., Manninen, M., Hwang, Y., Kim, T., & Yli-Piipari, S. (in review, 2022). Efficacy of lifestyle interventions to prevent and treat pediatric obesity: A systematic Review and Meta-analysis
14. Diener, E. D., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The satisfaction with life scale. *Journal of Personality Assessment*, 49(1), 71-75.
15. Dixon, B., Peña, M. M., & Taveras, E. M. (2012). Lifecourse approach to racial/ethnic disparities in childhood obesity. *Advances in Nutrition*, 3(1), 73-82

16. Djalalinia, S., Qorbani, M., Peykari, N., & Kelishadi, R. (2015). Health impacts of obesity. *Pakistan Journal of Medical Sciences*, 31(1), 23.
17. Evenson, K. R., Catellier, D. J., Gill, K., Ondrak, K. S., & McMurray, R. G. (2008). Calibration of two objective measures of physical activity for children. *Journal of Sports Sciences*, 26(14), 1557-1565.
18. Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, 39(2), 175-191.
19. Fogelholm, M., Stigman, S., Huisman, T., & Metsämuuronen, J. (2008). Physical fitness in adolescents with normal weight and overweight. *Scandinavian Journal of Medicine & Science in Sports*, 18(2), 162-170.
20. Friedemann Smith, C., Heneghan, C., & Ward, A. (2015). Moving focus from weight to health. What Are the components used in interventions to improve cardiovascular health in children?. *PLoS One*, 10(8), e0135115.
21. Fryar, C. D., Carroll, M. D., & Ogden, C. L. (2018). Prevalence of overweight, obesity, and severe obesity among children and adolescents aged 2–19 years: United States, 1963–1965 through 2015–2016.
22. Gadermann, A. M., Schonert-Reichl, K. A., & Zumbo, B. D. (2010). Investigating validity evidence of the satisfaction with life scale adapted for children. *Social Indicators Research*, 96(2), 229-247.
23. Gillet, N., Berjot, S., Vallerand, R. J., & Amoura, S. (2012). The role of autonomy support and motivation in the prediction of interest and drop-out intentions in sport and education settings. *Basic and Applied Social Psychology*, 34, 278–286.
24. Hardy, L. L., Jin, K., Mhrshahi, S., & Ding, D. (2019). Trends in overweight, obesity, and waist-to-height ratio among Australian children from linguistically diverse backgrounds, 1997 to 2015. *International Journal of Obesity*, 43(1), 116-124.
25. Haughton, C. F., Silfee, V. J., Wang, M. L., Lopez-Cepero, A. C., Estabrook, D. P., Frisard, C., ... & Lemon, S. C. (2018). Racial/ethnic representation in lifestyle weight loss intervention studies in the United States: a systematic review. *Preventive Medicine Reports*, 9, 131-137.
26. Hay, J., Maximova, K., Durksen, A., Carson, V., Rinaldi, R. L., Torrance, B., ... & McGavock, J. (2012). Physical activity intensity and cardiometabolic risk in youth. *Archives of Pediatrics & Adolescent Medicine*, 166(11), 1022-1029.
27. Ho, M., Garnett, S. P., Baur, L. A., Burrows, T., Stewart, L., Neve, M., & Collins, C. (2013). Impact of dietary and exercise interventions on weight change and metabolic outcomes in obese children and adolescents: A systematic review and meta-analysis of randomized trials. *JAMA Pediatrics*, 167(8), 759-768.
28. Ho, M., Garnett, S. P., Baur, L., Burrows, T., Stewart, L., Neve, M., & Collins, C. (2012). Effectiveness of lifestyle interventions in child obesity: Systematic review with meta-analysis. *Pediatrics*, 130(6), e1647-e1671.
29. Hughes, A. R., Summer, S. S., Ollberding, N. J., Benken, L. A., & Kalkwarf, H. J. (2017). Comparison of an interviewer-administered with an automated self-administered 24 h (ASA24) dietary recall in adolescents. *Public Health Nutrition*, 20(17), 3060-3067.

30. Isasi, C. R., Rastogi, D., & Molina, K. (2016). Health issues in Hispanic/Latino youth. *Journal of Latina/o Psychology*, 4(2), 67.
31. Janicke, D. M., Steele, R. G., Gayes, L. A., Lim, C. S., Clifford, L. M., Schneider, E. M., ... & Westen, S. (2014). Systematic review and meta-analysis of comprehensive behavioral family lifestyle interventions addressing pediatric obesity. *Journal of Pediatric Psychology*, 39(8), 809-825.
32. Jiwani, S. S., Carrillo-Larco, R. M., Hernández-Vásquez, A., Barrientos-Gutiérrez, T., Basto-Abreu, A., Gutierrez, L., ... & Miranda, J. J. (2019). The shift of obesity burden by socioeconomic status between 1998 and 2017 in Latin America and the Caribbean: a cross-sectional series study. *The Lancet Global Health*, 7(12), e1644-e1654.
33. Jones-Smith, J. C., Dieckmann, M. G., Gottlieb, L., Chow, J., & Fernald, L. C. (2014). Socioeconomic status and trajectory of overweight from birth to mid-childhood: The early childhood longitudinal study-birth cohort. *PloS One*, 9(6), e100181.
34. Joschtel, B., Gomersall, S. R., Tweedy, S., Petsky, H., Chang, A. B., & Trost, S. G. (2018). Effects of exercise training on physical and psychosocial health in children with chronic respiratory disease: A systematic review and meta-analysis. *BMJ Open Sport & Exercise Medicine*, 4(1), e000409.
35. Kang, M., Ragan, B. G., & Park, J. H. (2008). Issues in outcomes research: An overview of randomization techniques for clinical trials. *Journal of athletic training*, 43(2), 215-221.
36. Kitzmann, K. M., Dalton III, W. T., Stanley, C. M., Beech, B. M., Reeves, T. P., Buscemi, J., ... & Midgett, E. L. (2010). Lifestyle interventions for youth who are overweight: A meta-analytic review. *Health Psychology*, 29(1), 91.
37. Lassi, Z. S., Moin, A., Das, J. K., Salam, R. A., & Bhutta, Z. A. (2017). Systematic review on evidence-based adolescent nutrition interventions. *Annals of the New York Academy of Sciences*, 1393(1), 34-50.
38. Lesinski, M., Herz, M., Schmelcher, A., & Granacher, U. (2020). Effects of resistance training on physical fitness in healthy children and adolescents: An umbrella review. *Sports Medicine*, 50(11), 1901-1928.
39. Luckner, H., Moss, J. R., & Gericke, C. A. (2012). Effectiveness of interventions to promote healthy weight in general populations of children and adults: A meta-analysis. *The European Journal of Public Health*, 22(4), 491-497.
40. Manninen, M., Deng, Y., Hwang, Y., Waller, S., & Yli-Piipari, S. (2022). Psychological need-supportive instruction improves novel skill performance, intrinsic motivation, and enjoyment: A cluster-randomised study. *International Journal of Sport and Exercise Psychology*, 20(1), 122-146.
41. Manninen, M., Dishman, R., Hwang, Y., Magrum, E., Deng, Y., & Yli-Piipari, S. (2022). Self-determination theory based instructional interventions and motivational regulations in organized physical activity: A systematic review and multivariate meta-analysis. *Psychology of Sport and Exercise*, 102248.
42. Markland, D., & Tobin, V. (2004). A modification to the behavioural regulation in exercise questionnaire to include an assessment of amotivation. *Journal of Sport and Exercise Psychology*, 26(2), 191-196.

43. Mayr, H. L., Cohen, F., Isenring, E., Soenen, S., & Marshall, S. (2020). Multidisciplinary lifestyle intervention in children and adolescents-results of the project GRIT (Growth, Resilience, Insights, Thrive) pilot study. *BMC Pediatrics*, 20(1), 1-16.
44. McGovern, L., Johnson, J. N., Paulo, R., Hettinger, A., Singhal, V., Kamath, C., ... & Montori, V. M. (2008). Treatment of pediatric obesity: A systematic review and meta-analysis of randomized trials. *The Journal of Clinical Endocrinology & Metabolism*, 93(12), 4600-4605.
45. Metcalf, B., Henley, W., & Wilkin, T. (2012). Effectiveness of intervention on physical activity of children: Systematic review and meta-analysis of controlled trials with objectively measured outcomes (EarlyBird 54). *Bmj*, 345.
46. Min, J., Goodale, H., Xue, H., Brey, R., & Wang, Y. (2021). Racial-ethnic disparities in obesity and biological, behavioral, and sociocultural influences in the United States: A systematic review. *Advances in Nutrition*, 12(4), 1137-1148.
47. Moncada-Jiménez, J., & Carazo-Vargas, P. (2015). A meta-analysis on the effects of exercise training on the VO2max in children and adolescents. *Retos. Nuevas tendencias en Educación Física, Deporte y Recreación*, (27), 184-187.
48. Moroshko, I., Brennan, L., & O'Brien, P. (2011). Predictors of dropout in weight loss interventions: A systematic review of the literature. *Obesity Reviews*, 12(11), 912-934.
49. Ogden, C. L., Fryar, C. D., Martin, C. B., Freedman, D. S., Carroll, M. D., Gu, Q., & Hales, C. M. (2020). Trends in obesity prevalence by race and Hispanic origin—1999-2000 to 2017-2018. *Jama*, 324(12), 1208-1210.
50. Okorodudu, D. O., Jumeau, M. F., Montori, V. M., Romero-Corral, A., Somers, V. K., Erwin, P. J., & Lopez-Jimenez, F. (2010). Diagnostic performance of body mass index to identify obesity as defined by body adiposity: A systematic review and meta-analysis. *International Journal of Obesity*, 34(5), 791-799.
51. Olds, T., Tomkinson, G., Léger, L., & Cazorla, G. (2006). Worldwide variation in the performance of children and adolescents: an analysis of 109 studies of the 20-m shuttle run test in 37 countries. *Journal of Sports Sciences*, 24(10), 1025-1038.
52. Owens, S., Galloway, R., & Gutin, B. (2017). The case for vigorous physical activity in youth. *American Journal of Lifestyle Medicine*, 11(2), 96-115.
53. Parikh, T., & Stratton, G. (2011). Influence of intensity of physical activity on adiposity and cardiorespiratory fitness in 5–18 year olds. *Sports Medicine*, 41(6), 477-488.
54. Patsopoulou, A., Tsimtsiou, Z., Katsioulis, A., Malissiova, E., Rachiotis, G., & Hadjichristodoulou, C. (2017). Evaluating the efficacy of the feeding exercise randomized trial in overweight and obese adolescents. *Childhood Obesity*, 13(2), 128-137.
55. Payne, V. G., Morrow Jr, J. R., Johnson, L., & Dalton, S. N. (1997). Resistance training in children and youth: A meta-analysis. *Research Quarterly for Exercise and Sport*, 68(1), 80-88.
56. Peirson, L., Fitzpatrick-Lewis, D., Morrison, K., Ciliska, D., Kenny, M., Ali, M. U., & Raina, P. (2015). Prevention of overweight and obesity in children and youth: A systematic review and meta-analysis. *Canadian Medical Association Open Access Journal*, 3(1), E23-E33.

57. Pelletier, L. G., Fortier, M. S., Vallerand, R. J., & Briere, N. M. (2001). Associations among perceived autonomy support, forms of self-regulation, and persistence: A prospective study. *Motivation and Emotion*, 25, 279–306.
58. Perez, L. G., Arredondo, E. M., Elder, J. P., Barquera, S., Nagle, B., & Holub, C. K. (2013). Evidence-based obesity treatment interventions for Latino adults in the US: A systematic review. *American Journal of Preventive Medicine*, 44(5), 550-560.
59. Pew Research Center. 2019 National and state population estimates. Available at <https://www.census.gov/newsroom/press-kits/2019/national-state-estimates.html>. Accessed May 30th, 2021
60. Plowman, S. A., & Meredith, M. D. (2013). Reference guide.
61. Psaltopoulou, T., Tzanninis, S., Ntanasis-Stathopoulos, I., Panotopoulos, G., Kostopoulou, M., Tzanninis, I. G., ... & Sergentanis, T. N. (2019). Prevention and treatment of childhood and adolescent obesity: A systematic review of meta-analyses. *World Journal of Pediatrics*, 15(4), 350-381.
62. Reinehr, T. (2013). Lifestyle intervention in childhood obesity: Changes and challenges. *Nature Reviews Endocrinology*, 9(10), 607–614
63. Rottensteiner, C., Happonen, L., & Kontinen, N. (2015). The interplay of autonomous and controlled motivation in youth team sports. *International Journal of Sport Psychology*, 46, 225–243
64. Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Publications.
65. Salam, R. A., Padhani, Z. A., Das, J. K., Shaikh, A. Y., Hoodbhoy, Z., Jeelani, S. M., ... & Bhutta, Z. A. (2020). Effects of lifestyle modification interventions to prevent and manage child and adolescent obesity: A systematic review and meta-analysis. *Nutrients*, 12(8), 2208.
66. Stoner, L., Rowlands, D., Morrison, A., Credeur, D., Hamlin, M., Gaffney, K., ... & Matheson, A. (2016). Efficacy of exercise intervention for weight loss in overweight and obese adolescents: Meta-analysis and implications. *Sports Medicine*, 46(11), 1737-1751.
67. Styne, D. M., Arslanian, S. A., Connor, E. L., Farooqi, I. S., Murad, M. H., Silverstein, J. H., & Yanovski, J. A. (2017). Pediatric obesity—assessment, treatment, and prevention: An Endocrine Society clinical practice guideline. *The Journal of Clinical Endocrinology & Metabolism*, 102(3), 709-757.
68. Subar, A. F., Kirkpatrick, S. I., Mittl, B., Zimmerman, T. P., Thompson, F. E., Bingley, C., ... & Potischman, N. (2012). The automated self-administered 24-hour dietary recall (ASA24): A resource for researchers, clinicians and educators from the National Cancer Institute. *Journal of the Academy of Nutrition and Dietetics*, 112(8), 1134.
69. Tovar, A., Renzaho, A., Guerrero, A. D., Mena, N., & Ayala, G. X. (2014). A systematic review of obesity prevention intervention studies among immigrant populations in the US. *Current Obesity Reports*, 3(2), 206-222.
70. Tovar, A., Renzaho, A., Guerrero, A. D., Mena, N., & Ayala, G. X. (2014). A systematic review of obesity prevention intervention studies among immigrant populations in the US. *Current Obesity Reports*, 3(2), 206-222.
71. US Department of Health and Human Services. (2019). US Department of Agriculture. 2015–2020 dietary guidelines for Americans.

72. Williams, G. C., Grow, V. M., Freedman, Z. R., Ryan, R. M., & Deci, E. L. (1996). Motivational predictors of weight loss and weight-loss maintenance. *Journal of Personality and Social Psychology*, 70(1), 115.
73. Williams, G. C., McGregor, H. A., Zeldman, A., Freedman, Z. R., & Deci, E. L. (2004). Testing a self-determination theory process model for promoting glycemic control through diabetes self-management. *Health Psychology*, 23(1), 58.
74. Wittmeier, K. D., Mollard, R. C., & Kriellaars, D. J. (2008). Physical activity intensity and risk of overweight and adiposity in children. *Obesity*, 16(2), 415-420.
75. Yang, S., Qiu, L., Xiao, J., & Luo, C. (2021). The effects of resistance training on children with burns: A meta-analysis. *Pediatric Surgery International*, 37(10), 1323-1332.
76. Zabinski, M. F., Saelens, B. E., Stein, R. I., Hayden-Wade, H. A., & Wilfley, D. E. (2003). Overweight children's barriers to and support for physical activity. *Obesity Research*, 11(2), 23

Table 4.1. Summary of Effect Size on Outcome Measures

Name	k	Sample Characteristics	Outcome Measures	Effect Size
Berge & Everts, 2011	20	Sampling: unknown Age: 2-15	BMI percentile, BMI z	BMI percentile: -.50; ES small BMIz: -.36; ES small
Ho et al., 2012	38	Age ≤ 18 Sampling: unknown	BMI, BMI z	BMI: -1.25 kg/m ² , (95% CI [-2.18, -.32]); ES moderate BMIz: -.10 (95% CI [-.18, -.02]); ES small
Joschtel et al., 2008	24	Age: 8-20 Sampling: 1009	Cardiovascular endurance	VO ₂ Peak: 1.16 (95% CI [.61, 1.70])
Lesinski, Herz, Schmelcher, & Granacher, 2021		Age: ≤ 18 Sampling: 11	Muscle strength	Muscle strength: $.54 \leq \text{SMD} \leq 1.12$), ES medium-to-large
Luckner, Moss, & Gericke, 2012	6	Age ≤ 18 Sampling: 10257	BMI	BMI: .1 kg/m ² (95% CI [-.17, -.04]); ES small
Payne, Morrow, Johnson, Dalton, & 1997	28	Age: ≤ 18 Sampling 252	Muscle strength and endurance	.75 (n.a., $p < .05$); 63% (n.a.), ES moderate
Peirson et al., 2015	123	Age: 0-18 Sampling: unknown	BMI BMIz	BMI: -.09 kg/m ² (95% CI [-.16, -.03]); ES small BMIz: -.07, (95% CI [-.10, -.03]); ES small
Salam et al., 2020	5	Age ≤ 18	BMIz	BMIz: -.13; (95% CI [-.25, .00]); ES small

Stoner et al., 2016	13	Sampling: 1806 Age: unknown Sampling 556	BMI	BMI: -2.0 kg/m ² (95 % CI [1.5, -2.5]); ES moderate
			WC	WC: 3.0 cm (95 % CI [1.3, 4.8]); ES small
Yang, Qiu, & Luo, 2021	24	Age unknown Sampling: 379	Cardiovascular endurance	VO ² peak: 5.83, (95% CI [3.52, 8.13]); ES moderate

Table 4.2. Intervention Content Outlines

Dates	Exercise	Nutrition
Week 1	Circuit Training I & Circuit Training II	Goal Setting
Week 2	Circuit Training & No-Contact Martial Arts	Food Groups Friends
Week 3	No-Contact Martial Arts & Circuit training	MyPlate: Discovery Trail
Week 4	Circuit Training & Workout Blast	MyPlate: Eat the Colors
Week 5	Workout Bingo & Circuit Training	MyPlate: Avoid Sugary Beverages
Week 6	Circuit Training & Spelling Game	MyPlate: Be Whole Go Whole Grain
Week 7	No-Contact Boxing I & II	MyPlate: Dietary Fats, Knowing the Types
Week 8	Circuit Training & Yoga	MyPlate: Reduce Trans/Saturated Fats
Week 9	Yoga & Circuit Training	MyPlate: Rock Your Snacks
Week 10	Spelling Game & Workout Blast	MyPlate: Drink up Dairy Daily
Week 11	Workout Bingo & Circuit Training	MyPlate: Creating a Healthy Environment
Week 12	Circuit Training & Spelling Game	Bring it All Together

Table 4.3. Need-supportive Motivational Strategies

Motivational Strategies	Examples
1. Use non-controlling, informational language	Next, we will do.; Next, we can do.; Next, we can try.
2. Provide meaningful choice	Today's exercises are focusing especially on your calf muscles.
3. Provide choice	You can select inclined push-ups instead of floor push-ups; Control the depth of the lunges based on your feelings
4. Orient to intrinsic values and goals	These exercises make you improve your muscle endurance.; Do you feel how your muscles are working?
5. Offer, constructive, clear and relevant feedback	Thanks for your hard work everyone!; Great work, [name]. You really had great intensity today.
6. Take a participant perspective	I understand that these workouts can be difficult and tired for you sometimes, but these workouts will help us to be healthier and stronger.
7. Demonstrate interest in a participant as a person	[Name], how was your school today?
8. Prompt participants to pose questions or contribute to discussions	Do you have any questions about our objectives today?

Table 4.4. Baseline Participants Characteristics

Variable	Comparison (mean $\pm$ SD)	Intervention (mean $\pm$ SD)
Age	13.25 $\pm$ 1.52	13.15 $\pm$ 1.60
Gender (n; boys/girls)	11/9	13/7
Boys' pubertal stage (%)		
Pre-early pubertal	9.1%	23.0%
Mid-pubertal	54.5%	38.5%
Late-post pubertal	36.4	38.5%
Girls' pubertal stage (%)		
Pre-early pubertal	22.2%	28.6%
Mid-pubertal	66.7%	71.4%
Late-post pubertal	11.1%	0
Baseline BMI n (%)		
>25-29.9 kg/m ²	8 (40)	5(25)
>30 kg/m ²	12(60)	15(75)
Posttest BMI n (%)		
>25-29.9 kg/m ²	7(35)	3(25)
>30 kg/m ²	13(65)	9(75)
Follow-up BMI n (%)		
>25-29.9 kg/m ²	6 (30)	4(33.33)
>30 kg/m ²	13(70)	8(67.77)

Table 4.5. Characteristics of the Study Variables

Variables	Full Sample (<i>N</i> =40)			Experimental Group (<i>n</i> =20)			Control Group (<i>n</i> =22)		
	Baseline	Posttest	Follow-up	Baseline	Posttest	Follow-Up	Baseline	Posttest	Follow-Up
Weight (kg)	82.72±17.61	82.46±16.68	84.07±16.70	87.03±22.04	84.58±22.51	85.46±22.51	78.41 ±10.57	81.19±12.49	83.22±12.63
Height (cm)	160.79±7.90	160.78±6.87	160.99±6.88	160.65±9.82	160.30±9.07	160.85±8.77	160.93±5.61	161.07±5.41	161.07±5.39
BMI (kg/m ²)	32.49±4.64	32.46±4.91	32.94±5.04	35.09±5.45	33.51±6.09	33.37±6.49	30.84± 3.30	31.84±4.09	32.67±4.10
BMI-z	.00±.99	.00±.98	.00±.98	.18±1.04	.00±1.00	.00±1.00	.00±1.00	.00±1.00	.00±1.00
WC (cm)	100.60±12.23	99.94±11.37	100.88±11.41	102.04±15.06	99.17±14.71	98.62±13.35	99.02± 8.33	100.40±9.22	102.24±10.25
PACER (laps)	9.97±3.27	9.35±3.62	8.42±3.90	10.93±3.64	11.27±4.53	10.00±4.54	9.20±2.80	8.30±3.10	7.55±3.30
Curl-up (reps)	15.14±10.84	17.74±12.89	16.74±13.70	15.43±15.84	25.54±18.56	23.64±20.82	14.9±4.27	13.45±5.15	12.95±5.05
Push-up (reps)	6.33±4.15	7.51±4.15	6.32±3.41	6.00±5.07	9.91±3.59	7.45±3.50	6.60±3.34	6.20±3.29	5.70±3.28
LPA (m/d)	445.60±137.53	413.21±117.92	449.35±103.03	422.96±150.0	335.16±79.83	390.94±82.27	468.23±123.48	460.05±102.57	480.10±101.17
MVPA (m/d)	183.63±83.38	165.32±73.53	153.50±68.23	191.37±88.27	175.06±79.82	158.78±71.13	175.90±79.70	159.48±70.97	150.72±68.47
VPA (m/d)	0	0	0	1.38±4.01	1.25±4.33	0	0	0	0
Steps	8,233.56±3,855.17	7,777.03±3,270.09	7,963.57±3,855.18	6,564.47±3,440.04	5,857.68±2,573.90	6,851.11±2,573.90	9,902.65±3578.82	8,928.64±3,195.57	8,549.08±2,923.99
Intrinsic Motivation	2.73±.89	2.41±1.09	2.24±.96	3.28±.65	3.35±1.02	3.12±.81	2.17±.676	1.85±.67	1.71±.57
Integrated Regulation	3.00±.74	2.73±.75	2.73±.75	3.53±.54	3.35±.66	3.35±.66	2.49±.52	2.35±.52	2.35±.53
Identified Regulation	3.01±.75	2.81±.74	2.65±.84	3.33±.79	3.18±.66	3.04±.96	2.70±.58	2.58±.70	2.43±.68
Introjected Regulation	3.08±.61	3.16±.64	3.15±.75	3.06±.60	2.94±.54	2.92±.83	3.11±.64	3.28±.68	3.29±.68
Extrinsic Regulation	2.92±.76	3.17±.91	3.31±.88	2.51±.64	2.38±.79	2.52±.73	3.33 ±.65	3.65±.60	3.79±.58
Amotivation	2.00±.67	3.02±.86	3.17±.82	3.13±.71	2.81±1.06	2.98±1.02	2.89±.63	3.13±.71	3.29±.67
Psychological well-being	2.64±1.21	2.03±1.14	2.23±1.21	3.35±1.12	3.64±1.08	3.47±.88	1.92±83	1.63±74	1.48±.62

Table 4.6. Between Groups Difference

Variable	Short-term			Longer-term		
	F-statistic	P-value	Es (η^2)	F-statistic	P-value	Es (η^2)
BMI	23.83	.001***	.45	26.58	.001***	.48
BMIz	2.14	.154	.07	1.35	.26	.04
WC	23.29	.001***	.45	24.32	.001***	.46
PACER (laps)	8.18	.008**	.23	2.60	.118	.09
Curl-up (reps)	22.92	.001***	.45	10.78	.003**	.28
Push-up (reps)	28.33	.001***	.50	5.08	.032*	.15
LPA	17.68	.001***	.38	8.71	.006**	.24
MPA	1.01	.322	.03	2.20	.149	.07
MVPA	.42	.521	.01	.37	.546	.01
VPA	.550	.464	.20	.00	NA	NA
Step	4.06	.053	.12	.35	.558	.01
Intrinsic Motivation	5.77	0.023*	.17	9.81	.004**	.25
Integrated Regulation	2.63	.115	.09	2.63	.115	.08
Identified Regulation	.11	.743	.00	.05	.823	.00
Introjected Regulation	3.59	.068	.11	2.85	.102	.09
Extrinsic Regulation	10.12	.003**	.26	11.89	.002**	.29
Amotivation	3.60	.068	.07	2.74	.109	.09
Psychological Well-being	33.82	.001***	.61	24.73	.001***	.46

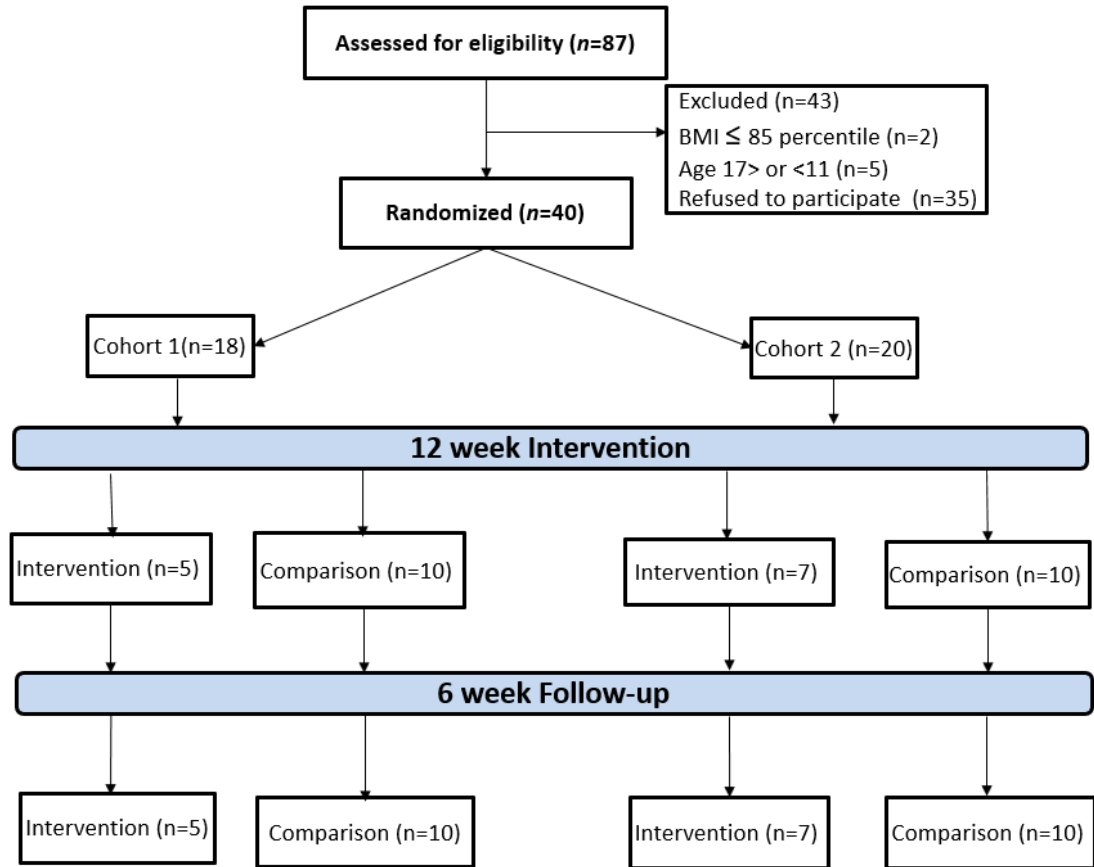


Figure 4.1. BRAVO lifestyle program recruitment process and flowchart

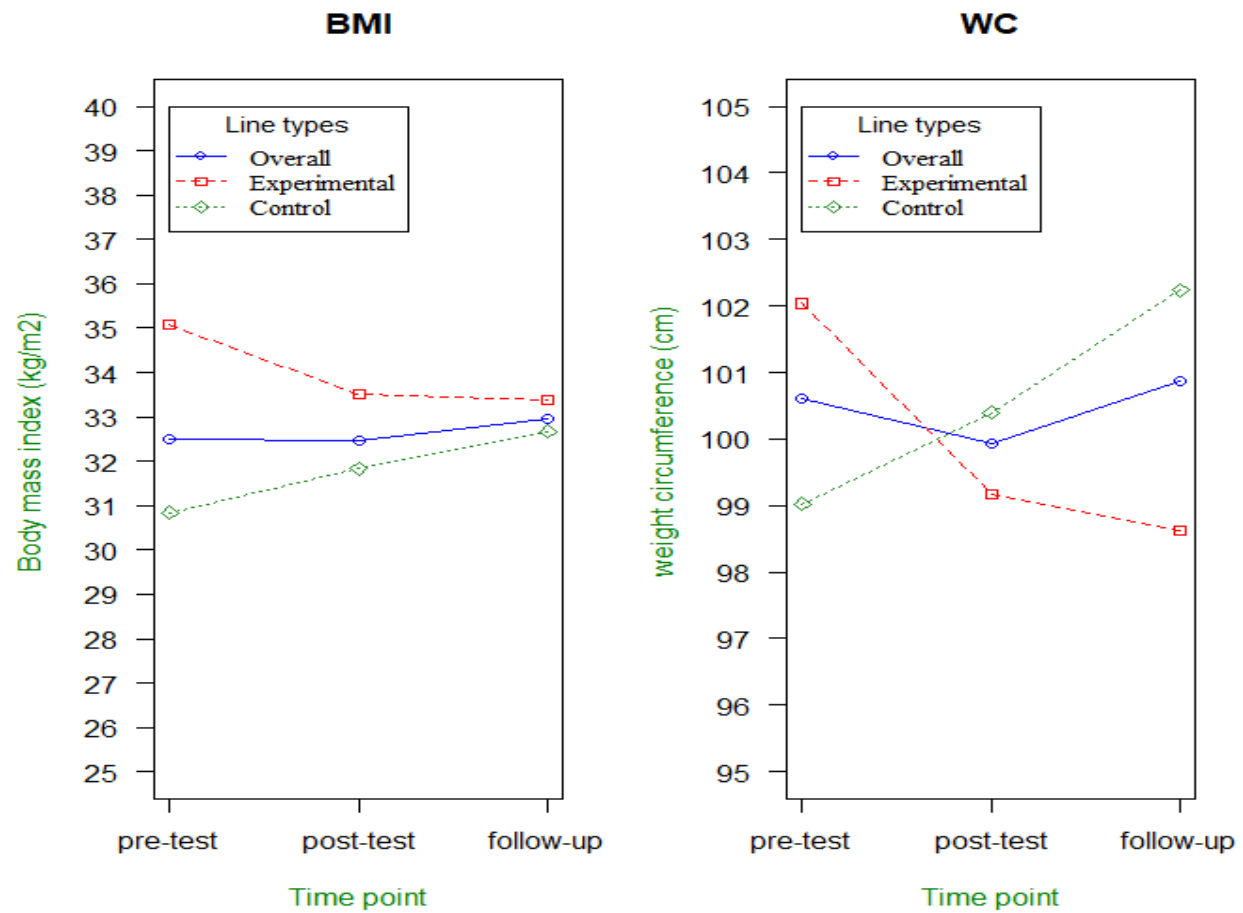


Figure 4.2. BMI and WC changes across the time

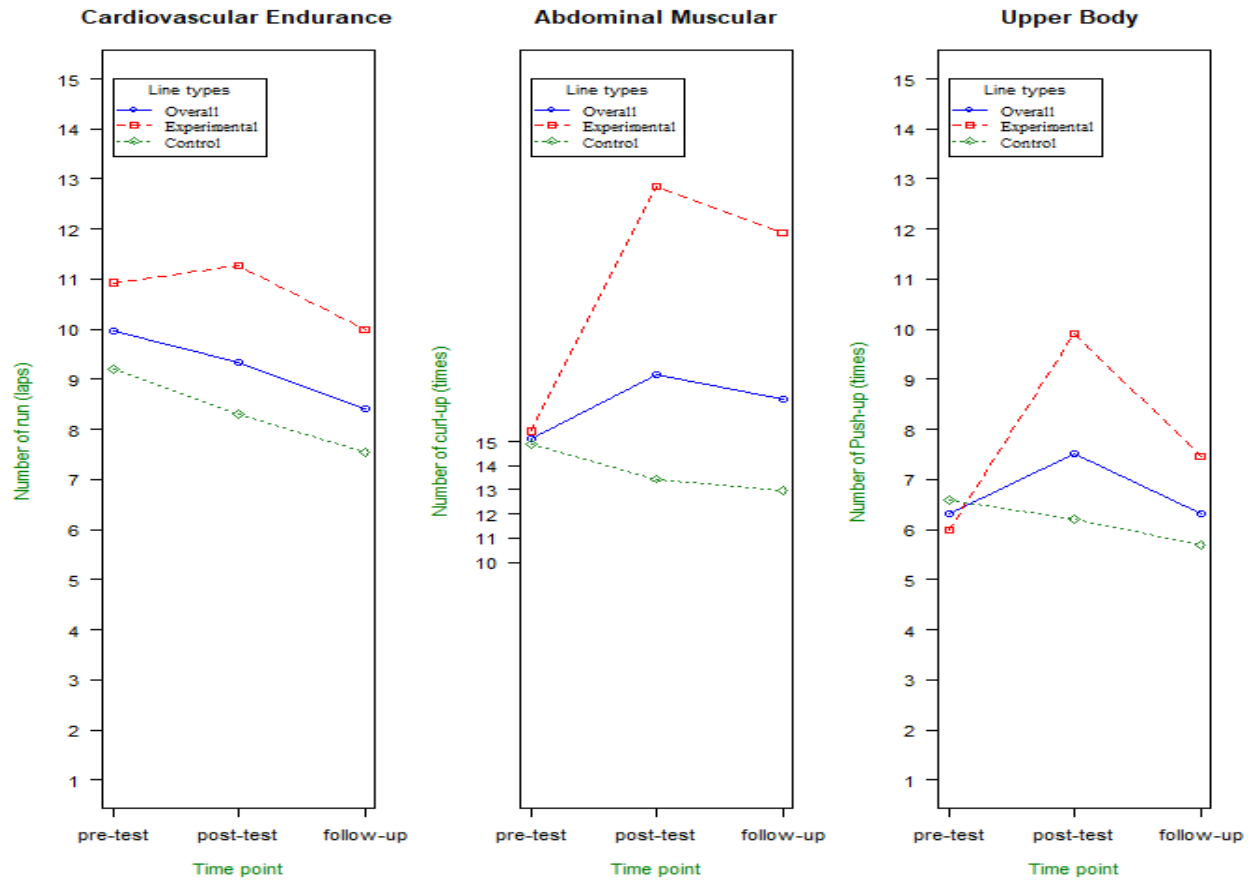


Figure 4.3. Changes in health-related fitness variables across the time

CHAPTER V

CONCLUSIONS

5.1 Primary Conclusions

This dissertation aimed to quantify the effects of the randomized controlled pediatric lifestyle interventions in treating overweight and obesity in adolescence. The second aim of the dissertation was to examine the efficacy of the psychological need-support centered BRAVO! lifestyle on the 12-week and longer-term changes in participants' body composition (BMI, BMIz, and WC) and health-related fitness (cardiovascular endurance, and muscular strength/endurance). Additionally, this study was to explore the changes in participants' PA and psychological outcomes, e.g., self-determined motivation and psychological well-being.

This study contributes to research evidence around lifestyle intervention programs as it provides an interesting insight into improving program adherence and long-term behavior change. The results supported the hypotheses suggesting that psychological need-support centered BRAVO! lifestyle program was effective in generating positive short- and longer-term changes in participants' body composition and health-related fitness. This dissertation study further indicates that intervention programs that incorporate psychological need-supportive strategies have shown to be more effective due to better program adoption, engagement, and retention (Teixeira, Carraça, Markland, Silva, & Ryan, 2012). Overall, this study showed that the BRAVO! program can be a feasible, effective tool in achieving short and longer-term health improvements in Hispanic adolescents with overweight and obesity.

The first study of the dissertation was a quantitative synthesis to examine the efficacy of 8 randomized controlled pediatric lifestyle interventions treating overweight and obesity among 11- to 17-year-old children. It was found that lifestyle interventions yield an average 1.77 kg/m^2 decline in participants' BMI. The size of this effect is similar compared to the findings of the previous meta-analyses (effect range in BMI from -1.25 to -2.0 kg/m^2 ; Berge & Everts, 2011; Stoner et al., 2016; Ho et al., 2012). Similarly, our findings targeting standardized changes in participants' BMI and WC, showed a .30 unit change and a 3.72 cm change for BMIz and WC, respectively. Overall, it was found that found lifestyle interventions consisting of actual exercise, not the recommendation only, yielded larger effect sizes compared to an intervention consisting of only an exercise recommendation. This finding indicates that lifestyle interventions that incorporate actual exercise are more likely to contribute to a greater program fidelity and participant effort. Future lifestyle intervention programs should incorporate actual exercise to improve the efficacious obesity and overweight program.

In addition, this dissertation contributes to the existing literature by exploring the efficacy of pediatric lifestyle interventions by examining several moderator variables. Moderator analyses suggested that the lifestyle interventions were most effective when participants were 13 to 15 years old and clearly obese. The findings further suggested that the effects of the lifestyle interventions were enhanced when an intervention was boosted with behavior modification components compared to the exercise-nutrition education-only interventions. Similarly, this study's findings corroborated previous studies that have shown longer-lasting interventions to be more effective in reducing BMI and WC (Bondyra-Wiśniewska, Myszkowska-Ryciak, & Harton, 2021). In conclusion, my results indicated that lifestyle interventions are effective in

treating overweight and obesity in children and adolescents. Interestingly, our results showed that behavior modification enhanced lifestyle interventions were more effective in reducing children's WC compared to exercise and nutrition education interventions. This finding is consistent with previous findings which have shown that a combination of diet, exercise, and behavioral modification is the most effective non-invasive strategy in reducing adolescent obesity (Elvsaas, Giske, Fure, & Juvet, 2017; Salam et al., 2020; Whitlock et al., 2010; Wilfley et al., 2007).

The second study of this dissertation focused on testing the efficacy of the BRAVO! lifestyle intervention on the 12-week and longer-term changes in participants' body composition (BMI, BMI-z, and WC) and health-related fitness (cardiovascular endurance, and muscular strength/endurance). The results showed there were statistically significant effects on BMI, WC, abdominal upper body, and abdomen muscular strength and endurance. These findings suggest that the BRAVO! lifestyle intervention can improve participants' weight status and reverse the negative health trend apparent in the control group participants. In addition, the findings showed that BRAVO! was effective in improving participants' cardiovascular endurance, upper body muscular strength/endurance, and abdominal muscular strength/endurance. These findings corroborated the findings of previous studies that have shown that lifestyle interventions can improve adolescents' fitness (Joschtel et al., 2018; Patsopoulou et al., 2017; Yang, Qiu, & Luo, 2021). This dissertation study extends the previous findings in the area of pediatric lifestyle interventions showing that psychological need-support centered lifestyle programs can have not only intervention lasting effects but also longer-term effects. These effects are pertinent in participants' WC and especially in participants' muscular strength and endurance.

In addition, BRAVO! was effective improving participants' motivational quality and psychological well-being. Specifically, BRAVO! was effective in improving intrinsic motivation and lowering extrinsic regulation. The central problem for any behavioral interventions is that the effects diminish quickly after the intervention and participants resume to their normal behavioral patterns easily. In regards to weight loss programs, Miller (2005) has shown that although people have more information about nutrition, exercise, and healthy lifestyle available than ever before, the reasons why people fail to adopt new health behaviors after the intervention are numerous. It has shown that the determining factor is not the knowledge but the adherence to behavioral change process that poses a problem and impedes lifestyle change (Miller, 2005). Although these conclusions are already dated, it is safe to say that available health information is certainly increased since the study by Miller (2005). In addition, the research has found that psychosocial factors, e.g., lack of motivation or low self-efficacy are predicates likely to prohibit long-term behavior change (Byrne, 2002). Although exploratory, these findings in regards to the improvements in self-determined motivation are promising. BRAVO! study applied a need-supportive approach focusing on supportive participants' psychological needs and empowerment. It is important to acknowledge that previous programs that have incorporated psychological need-supportive strategies have shown to be more effective due to better program adoption, engagement, and retention (Teixeira et al., 2012). In addition, research has shown need-support centered lifestyle interventions to be especially effective in overweight and obese adolescents. Specifically, intrinsic motivation as well as introjected and identified regulation have been shown to be linked with positive intervention outcomes, e.g., increased enjoyment (Rottensteiner, Happonen, & Kontinen, 2015), reduced drop-out intentions (Gillet, Berjot,

Vallerand, & Amoura, 2012), and greater exercise participation (Pelletier, Fortier, Vallerand, & Briere, 2001). These findings contribute to the tenets of positive psychology research centered around the self-determination theory, which collectively posits that designing programs harnessing participants' psychological needs plays a key role in improving program adherence and long-term behavior change.

BRAVO! lifestyle intervention was effective in improving psychological well-being compared to the control group. Previous research has found obese children and adolescents to have poorer psychological well-being, including body dissatisfaction, self-esteem, anxiety, depression, and low motivation (Erickson, Robinson, Haydel, & Killen, 2000; Wang & Veugelers, 2008; Wardle & Cooke, 2005). Although psychological well-being was examined as an exploratory variable, findings suggest that BRAVO! can greatly improve overweight and obese participants' psychological well-being which is a potentially important finding. It is noteworthy that this effect in well-being was evident in short term, but the evidence suggests that improvements in well-being stay up to six weeks after the intervention. Considering the challenges that young people face in terms of their psychological well-being and overweight (Wang & Veugelers, 2008), future intervention programs should measure changes, not only in weight-related factors but also psychological factors as improvement in psychological well-being are mental health in general maybe the most important factors impacting adolescents' quality of life.

5.2 Strengths and Limitations

Overall, this dissertation study had many strengths. Firstly, the meta-analysis utilized current best practices by the PRISMA protocol (Page et al., 2021). In addition, a multivariate approach

was used to ensure statistical rigor on my quantitative synthesis. Similarly, the BRAVO! lifestyle program was carefully designed to utilize evidenced-based practices. Thirdly, all exercise lessons and nutrition lessons were carefully prepared and semi-scripted, ensuring the similarity between different experimental cohorts. In addition, this study applied a randomized controlled approach to increase the external validity of the study. Utilizing the rigorous sampling strategy for this pilot study, the findings of this study provided limited feasibility and the data will be used to continue improving the program. Lastly, this study is novel as it emphasizes behavioral modification strategies that are evidence- and theory-based and centered around positive psychology research and self-determination theory. The meta-analyses concluded that lifestyle intervention efficacy can be improved when combining exercise and nutrition education with behavior modification strategies. These findings further shed a light on how need-support can improve longer-term intervention efficacy. These post-intervention findings are important as we are trying to better understand long-term behavior change.

Several limitations are related to this dissertation study. First, the sample size may limit the statistical power to detect statistically significant findings. The meta-analysis applied rigorous eligibility criteria and included only randomized controlled studies and lifestyle interventions. This strategy led to the relatively small meta-analysis sample size ($k = 8$). Similarly, for BRAVO! study, we had 32 participants completing the three data points. A fully powered sample size is needed for BRAVO! study to determine the smaller effects. In addition, the BRAVO! study was conducted during school years 2021 and 2022, and during COVID-19. It is safe to assume, that COVID-19 impacted BRAVO! sampling and attrition. In addition, COVID-19 has shown to be harmful for young adults' self-determined motivation, as it has

shown to decrease adaptive and increase maladaptive PA motivation (Deng, Hwang, Kim, & Yli-Piipari, 2022).

5.3. Conclusion

This dissertation showed that lifestyle interventions comprising of actual exercise training, nutrition education, and behavior modification strategies are moderately effective in improving overweight and obese adolescents' BMI, BMIz, and WC. Moderator analyses suggested that the type of the interventions, as well as participant age and weight status moderated the effect of lifestyle intervention on BMI and WC. Based on this, it can be recommended that the effectiveness of lifestyle interventions should incorporate behavior modification components to complement traditional exercise and nutrition education lifestyle interventions. This dissertation showed that BRAVO!, the psychological need-support centered lifestyle program, can be effective in improving at-risk Hispanic children's, body composition and, maybe more importantly, health-related fitness, self-determined motivation, and psychological well-being in the short and longer term.

5.4 Future Research

The findings of this study suggest several potential directions for future research on the treatment of Hispanic adolescents' unwanted overweight and obesity. Although our program showed high attendance rates among the participants, we have limited understanding of the role of program barriers, e.g., conflicting schedules, and financial constraints on the outcomes variables. Future research should understand the program implementation by examining the moderating or mediating roles of psychosocial, sociodemographic, and process implementation factors in reducing the risk factors among Hispanic adolescents with overweight and obesity.

This BRAVO!, the psychological need-support centered lifestyle program, was effective in improving at-risk Hispanic children not only in body composition but also in health-related fitness (upper body and abdominal muscular endurance/strength), in the short- and longer-term. Research has suggested that overweight or obese individuals and those with low cardiorespiratory fitness are less physically active and often have poorer mental health (Ruggero, Petrie, Sheinbein, Greenleaf, & Martin, 2015). Future research should focus more on improving overall health-related fitness and less focus on body composition.

Lifestyle interventions comprising of actual exercise training, nutrition education, and behavior modification had a moderate to large effect on BMI, BMIz, and WC. In addition, previous research found of successful lifestyle interventions for childhood obesity was performed as group treatment and found group treatment was more effective in reducing BMI than individual treatment (Oude et al., 2009; McGovern et al., 2008). BRAVO! program was a group-based program, but future research should examine the power of groups on obesity treatment.

Lastly, SDT has previously been found to be associated with program adherence and long-term behavior change (Deci & Ryan, 1985, 2000; Manninen et al., 2022). This finding contributes to the tenets of positive psychology research centered around the self-determination theory, which collectively posits that designing programs harnessing participants' psychological needs plays a key role in improving program adherence and long-term behavior change. In addition, future research on lifestyle intervention should consider SDT-based strategies to provide informational and positive feedback enhances students' perception of competence, and

provide optimal challenges and personal modifications for exercise to improve program adherence and longer-term obesity prevention.

5.5 References

1. Berge, J. M., & Everts, J. C. (2011). Family-based interventions targeting childhood obesity: A meta-analysis. *Childhood Obesity*, 7(2), 110-121.
2. Bondyra-Wiśniewska, B., Myszkowska-Ryciak, J., & Harton, A. (2021). Impact of lifestyle intervention programs for children and adolescents with overweight or obesity on body weight and selected cardiometabolic factors—A systematic review. *International Journal of Environmental, Research and Public Health*, 18(4), 2061
3. Byrne, S. M. (2002). Psychological aspects of weight maintenance and relapse in obesity. *Journal of Psychosomatic Research*, 53(5), 1029-1036.
4. Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum Press.
5. Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological inquiry*, 11(4), 227-268.
6. Deng, Y., Hwang, Y., Kim, T., & Yli-Piipari, S. (2022). Changes in college students' body mass index, physical activity, and motivation before and during the COVID-19 Third-wave lockdown. *International Journal of Kinesiology and Sports Science*, 10(2), 34-41.
7. Elvsaa, I. K. Ø., Giske, L., Fure, B., & Juvet, L. K. (2017). Multicomponent lifestyle interventions for treating overweight and obesity in children and adolescents: A systematic review and meta-analyses. *Journal of Obesity*, 2017.
8. Erickson, S. J., Robinson, T. N., Haydel, K. F., & Killen, J. D. (2000). Are overweight children unhappy?: Body mass index, depressive symptoms, and overweight concerns in elementary school children. *Archives of Pediatrics & Adolescent Medicine*, 154(9), 931-935.
9. Joschtel, B., Gomersall, S. R., Tweedy, S., Petsky, H., Chang, A. B., & Trost, S. G. (2018). Effects of exercise training on physical and psychosocial health in children with chronic respiratory disease: A systematic review and meta-analysis. *BMJ Open Sport & Exercise Medicine*, 4(1), e000409.
10. Manninen, M., Dishman, R., Hwang, Y., Magrum, E., Deng, Y., & Yli-Piipari, S. (2022). Self-determination theory based instructional interventions and motivational regulations in organized physical activity: A systematic review and multivariate meta-analysis. *Psychology of Sport and Exercise*, 102248.
11. McGovern, L., Johnson, J. N., Paulo, R., Hettinger, A., Singhal, V., Kamath, C., ... & Montori, V. M. (2008). Treatment of pediatric obesity: A systematic review and meta-analysis of randomized trials. *The Journal of Clinical Endocrinology & Metabolism*, 93(12), 4600-4605.
12. Miller, W. C. (2005). The weight-loss-at-any-cost environment: How to thrive with a health-centered focus. *Journal of Nutrition Education and Behavior*, 37, S89-S93.

13. Oude Luttikhuis, H., Baur, L., Jansen, H., Shrewsbury, V. A., O'malley, C., Stolk, R. P., & Summerbell, C. D. (2009). Cochrane review: Interventions for treating obesity in children. *Evidence-Based Child Health: A Cochrane Review Journal*, 4(4), 1571-1729.
14. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Bmj*, 372.
15. Ruggero, C. J., Petrie, T., Sheinbein, S., Greenleaf, C., & Martin, S. (2015). Cardiorespiratory fitness may help in protecting against depression among middle school adolescents. *Journal of Adolescent Health*, 57(1), 60-65.
16. Salam, R. A., Padhani, Z. A., Das, J. K., Shaikh, A. Y., Hoodbhoy, Z., Jeelani, S. M., ... & Bhutta, Z. A. (2020). Effects of lifestyle modification interventions to prevent and manage child and adolescent obesity: A systematic review and meta-analysis. *Nutrients*, 12(8), 2208.
17. Teixeira, P. J., Carraça, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, 9(1), 1-30.
18. Wang, F., & Veugelers, P. J. (2008). Self-esteem and cognitive development in the era of the childhood obesity epidemic. *Obesity Reviews*, 9(6), 615-623.
19. Stoner, L., Rowlands, D., Morrison, A., Credeur, D., Hamlin, M., Gaffney, K., ... & Matheson, A. (2016). Efficacy of exercise intervention for weight loss in overweight and obese adolescents: Meta-analysis and implications. *Sports Medicine*, 46(11), 1737-1751.
20. Ho, M., Garnett, S. P., Baur, L., Burrows, T., Stewart, L., Neve, M., & Collins, C. (2012). Effectiveness of lifestyle interventions in child obesity: Systematic review with meta-analysis. *Pediatrics*, 130(6), e1647-e1671.
- Wardle, J., & Cooke, L. (2005). The impact of obesity on psychological well-being. *Best Practice & Research Clinical Endocrinology & Metabolism*, 19(3), 421-440.
21. Whitlock, E. P., O'Connor, E. A., Williams, S. B., Beil, T. L., & Lutz, K. W. (2010). Effectiveness of weight management interventions in children: A targeted systematic review for the USPSTF. *Pediatrics*, 125(2), e396-e418.
22. Wilfley, D. E., Tibbs, T. L., Van Buren, D., Reach, K. P., Walker, M. S., & Epstein, L. H. (2007). Lifestyle interventions in the treatment of childhood overweight: A meta-analytic review of randomized controlled trials. *Health Psychology*, 26(5), 521.
23. Yang, S., Qiu, L., Xiao, J., & Luo, C. (2021). The effects of resistance training on children with burns: A meta-analysis. *Pediatric Surgery International*, 37(10), 1323-1332.
24. Patsopoulou, A., Tsimtsiou, Z., Katsioulis, A., Malissiova, E., Rachiotis, G., & Hadjichristodoulou, C. (2017). Evaluating the efficacy of the feeding exercise randomized trial in overweight and obese adolescents. *Childhood Obesity*, 13(2), 128-137.
25. Gillet, N., Berjot, S., Vallerand, R. J., Amoura, S., & Rosnet, E. (2012). Examining the motivation-performance relationship in competitive sport: A cluster-analytic approach. *International Journal of Sport Psychology*, 43(2), 79.

26. Pelletier, L. G., Fortier, M. S., Vallerand, R. J., & Briere, N. M. (2001). Associations among perceived autonomy support, forms of self-regulation, and persistence: A prospective study. *Motivation and Emotion*, 25(4), 279-306.
27. Rottensteiner, C., Happonen, L., & Konttinen, N. (2015). The interplay of autonomous and controlled motivation in youth team sports. *International Journal of Sport Psychology*, 46(3), 225-243.

APPENDICES

APPENDIX A

CONSENT FORM

Approved by University of Georgia
Institutional Review Board
Project ID PROJECT00003905
Approved on: 9/8/2021

**UNIVERSITY OF GEORGIA
PARENTAL PERMISSION FORM
An Examination of the BRAVO! Lifestyle Program**

Your child and you are being asked to take part in a research study. The information in this form will help you decide if you want to be in the study. Please ask the investigators below if there is anything that is not clear or if you need more information.

Principal Investigator: *Dr. Sami Yli-Piipari*
Department of Kinesiology
706-542-4462
syp@uga.edu

Co-Investigator: *Yangyang Deng*
Department of Kinesiology
yangyang.deng@uga.edu

The BRAVO! Lifestyle program provides exercise training for children and teaches parents and children about nutrition. We are doing this research study to learn more about how the BRAVO! lifestyle program affects health. The specific research question is to see if the BRAVO! lifestyle program changes body composition and fitness levels in Hispanic and African American children with weight-related health concerns.

Your child and you are being invited to be in this research study because you have indicated that your child may have some weight related concerns. Your child can participate if (s)he is Hispanic or African American, 11-16-years old, and reads/speaks English. Additionally, your child must be considered overweight or obese or have high blood sugar. Participating parents must be able to write and speak English.

You and your child will be randomly assigned either to the BRAVO! or the control group (i.e. by chance, like flipping a coin.) You will have a 50/50 chance of being assigned to either group.

If you agree to participate in this study (Both BRAVO! and control groups):

- We will measure your child's waist, weight, height, and body mass index. We will measure your child's fitness by asking them to do some exercises. Your child will be asked questions about their motivation and physical activity. Finally, we are asking your child to wear a physical activity tracker (like a wristwatch) and fill out a 3-day eating diary.
- We will ask you to visit University of Georgia's Center of Health and Physical Activity (Ramsey Building) three times. The first testing session will be before the BRAVO! Program starts (Week 0 – September 2021), the second testing session is after the 12-week program (Week 13 – December 2021), and third 6-weeks later (Week 19 – January 2022). Each visit will take about 60 minutes.

If you agree to participate in this study (BRAVO! group only):

- Exercise: Child participants are expected to participate in the exercise sessions. Each exercise session is 60 minutes long and the training sessions will be conducted twice a week (Tuesdays and Thursdays) for 12 consecutive weeks. Each training session follows the same structure of (a) 10 minutes of warm-up and dynamic stretches, (b) 40 minutes of modified exercise, such as circuit training, Tae Kwon Do, Boxing, Yoga, and game-based exercises focusing on cardiovascular and muscle endurance and muscle strength, and (c) 10 minutes of a closure huddle with stretching. Tae Kwon Do and Boxing are solo fitness activities, so there will be no physical contact between participants. Exercise sessions will be moderate/vigorous in intensity. In other words, this means that activities can make your child sweat and breathe harder than when sitting in a chair.

APPENDIX B

ASSENT FORM

Approved by University of Georgia
Institutional Review Board
Project ID PROJECT00003905
Approved on: 9/8/2021

- Measures at Each Exercise Session: We will record your child's attendance. Your child will wear a heart rate monitor so we can record their heart rate. Your child will be asked how hard they are exercising and will fill out a survey about their feelings while participating in the program.
- Nutrition Education: You and your child are asked to participate in the nutrition education. The nutrition education is a 30-minute educational session once a week (Thursdays) for 12-weeks. The content of the sessions will include nutritional topics, e.g. the importance of fruits and vegetables, reducing harmful fats intake, reducing sugar-sweetened beverage intake, choosing whole grains, and eating healthy away from home, as well as behavioral topics such as goal setting and self-monitoring.
- The time commitment for these sessions will be 32 hours for a child and 6 hours for a guardian. The total time commitment includes transportation to and from the sessions and may include waiting for children in sessions. You have an option to drop your children off at Ramsey 101, or you can wait at the Ramsey building lobby in the front of the Center of Health and Physical Activity.

If you agree to participate in this study (Control group only):

- If you and your child have been selected to participate in the control group, you will not receive the exercise and nutrition program at first, but can join the program at a later date (in fall 2021 or spring 2022) if you wish.

Participation is voluntary. You, or your child, can refuse to take part or stop at any time without penalty or loss of benefits.

There are some minimal risks associated with this study. First, some questions may make your child uncomfortable. (S)he can skip these questions if (s)he does not wish to answer them. Some of the exercise may be hard for the participants. To avoid that, participants are offered alternative exercises to match their current fitness status and motivation. If some of the activities are too hard, your child will be encouraged to stop, and inform the instructors that (s)he needs a break. Additionally, your child may experience some soreness and tiredness that is normal when participating in exercise or physical education class. To minimize these risks, your child will be offered activities that are suitable for their current fitness levels. Finally, there is a small risk that your child can experience an exercise-related injury. This risk is very small, smaller than risks in supervised physical education class or sport training. Your child will be supervised by a member of the research team the entire time from the drop off to pick up, including moving from the gym (101d) to the nutrition education classes R104 (distance 20 yards) or short visits to restrooms (distance 10 yards).

Your participation in this research study will help us to understand the ways nutrition and exercise can improve children's health. In addition, children in the BRAVO! Group are expected to improve their health which can prevent future diseases.

We will take steps to protect your privacy, but there is a small risk that your information could be accidentally disclosed to people not connected to the research. To reduce this risk, we will remove your name from the data, and replace it with an ID number. The list linking the code to you and your child will be kept separately from the other study records and will be destroyed immediately after completing the data collection. The study records may be reviewed by departments at the University of Georgia responsible for regulatory and research oversight. The study team will not release identifiable results of the study to anyone other than individuals working on the project without your written consent unless required by law. These data will not be used for future research. Confidentiality will be broken if you or your child reports, or we suspect, abuse and/or neglect of a child, as required by law.

This research involves the transmission of data over the Internet. Every reasonable effort has been taken to ensure the effective use of available technology; however, confidentiality during online communication cannot be guaranteed.

In the event that any research-related activities result in an injury or illness, the sole responsibility of the investigators will be to arrange for your child's transportation to an appropriate health care facility. If you think that your child has suffered a research-related injury, you should seek immediate medical attention and then contact Dr. Yli-Piipari right away at 901-233-1019. Medical expenses will be your responsibility or that of your third-party payer (insurance). However, you cannot be prevented from seeking to collect compensation for injury related to malpractice, fault, or blame on the part of those involved in the research.

Transportation to the testing site will be your responsibility.

The main researchers conducting this study are Yangyang Deng & Dr. Sami Yli-Piipari at the University of Georgia. Please feel free to ask questions about this research at any time. You can contact the Principal Investigator, Dr. Sami Yli-Piipari 706-542-4462, syp@uga.edu. If you have any complaints or questions about your rights as a research volunteer, contact the IRB at 706-542-3199 or by email at IRB@uga.edu.

If you agree to participate in this research study, please sign below:

_____ Name of Researcher	_____ Signature	_____ Date
_____ Name of Parent Participant	_____ Signature	_____ Date
_____ Name of Child Participant		

Please keep one copy and return the signed copy to the researcher.

APPENDIX C

SCREENING FORM

Assent for Participation in Research An Examination of the BRAVO! Lifestyle Program

We are asking you to be in a research study to test the effect of the BRAVO! Lifestyle Program. You can be randomly (by chance) assigned to the BRAVO! or control group. If you are selected to participate in the BRAVO! group, you will attend group exercise and nutrition classes. Each exercise session is 60 minutes long and the sessions will be conducted twice a week, whereas nutrition education classes are 30 minutes long conducted once a week. Total time commitment is 19 weeks, including pretests, 12 weeks of exercise training and nutrition education, post-tests, and a follow-up. If you are in the control group, you will not attend the exercise and nutrition classes. Both groups will be asked to come to our lab three times. Each lab visit includes the following tests: an online questionnaire, height and weight measures, and fitness tests.

If you agree to be in this study, you will be asked to answer questions about your health, your body, your physical activity, your emotions (like, how you are feeling), and what you usually eat and drink. This will all be split over three visits.

You do not have to say "yes" if you don't want to. No one, including your caregiver, will be upset with you if you say "no" now or if you change your mind later. We have also asked your caregiver's permission to do this. Even if your caregiver says "yes," you can still say "no." Remember, you can ask us to stop at any time. Your grades in school will not be affected whether you say "yes" or "no."

All information you share with us is private. The only exception to this rule is if you tell us that you or another child is being hurt in some way, or if you are thinking of hurting yourself. If that were happening, we would tell someone to help keep you or the other child safe.

You can ask any questions that you have about this study. If you have a question later that you didn't think of now, you can contact Dr. Sami Yli-Piipari (syp@uga.edu 706-542-4462) anytime.

Name of Adolescent: _____
Guardian Permission on File: ☐ Yes ☐ No**

(For Written Assent) Signing here means that you have read this paper or had it read to you and that you are willing to be in this study. If you don't want to be in the study, don't sign.

Signature of Adolescent: _____ Date: _____

Signature of Researcher: _____ Date: _____

APPENDIX C

SCREENING FORM

Subject No. [][] [][]	Date of Screen [][] [][] [][] [][] MM DD YYYY	Form filled out by: [][] [][]	Data entered by: [][] [][]
-------------------------------------	--	---	--

Screening Form & Consent Script

Name: _____ Phone Number: _____ Email: _____

Remove name above or recode if enrolled

Screening Form & Consent Script

Interviewer: _____ Date: _____ Assigned Screening ID: _____

"BRAVO! Lifestyle Program"

We are calling you because you have indicated that you and your child are interested in participating in the BRAVO! research study conducted at the UGA. My name is _____, and I would like to ask you a few questions to determine whether you and your child are eligible for this study. Before I begin the screening, I would like to tell you a little bit about this research study.

The purpose of the research is to learn more about the effectiveness of the BRAVO! lifestyle intervention. The BRAVO! lifestyle intervention program provides exercise training for children and teaches parents and children about nutrition. We are doing this research study to learn more about how the BRAVO! lifestyle program affects health. The specific research question is to see if the BRAVO! lifestyle program changes body composition and fitness levels in Hispanic and African American children with weight-related health concerns. This program will run from Sep 14th, 2021 through Dec 2nd, 2021 on Tuesday and Thursday (group one, 5:45-6:45 pm; group two, 7:00- 8:00 pm). The nutrition class will be offered every Thursday (group one, 6:45-7:15 pm; group 2, 8:00-8:30 pm), and a parent is asked to participate with their child in the nutrition session. The research activities, such as data collection, exercise training and nutrition education will take place in the Center of Health and Physical Activity at the UGA's Ramsey Student Health Center.

Would you like to continue with the screening? The screening will take about 10 minutes.

[If no, person can leave]

[If yes, continue with the screening - please include all screening questions in this script]

05/30/2021

Subject No.	Date of Screen	Form filled out by:	Data entered by:
 	 MM DD YYYY	 	

CHECKLIST		0 = Excludes 1 = Includes	NOTES
Can you read and write in English?	₁ ☐ Yes ₀ ☐ No		
Is your child between 11 and 16 years old?	₁ ☐ Yes ₀ ☐ No		
Is your child Hispanic or African American?	₁ ☐ Yes ₀ ☐ No		
Does your child have at least one of these health concerns: overweight, obesity, or high blood sugar?	₁ ☐ Yes ₀ ☐ No		
Do you think or has your family pediatrician indicated that your child is overweight?	₁ ☐ Yes ₀ ☐ No		
Can your child read and write in English?	₁ ☐ Yes ₀ ☐ No		
Is your child taking medication(s) that influence physical activity or cognition? (e.g. long-acting sleeping pills like Lunesta [eszopiclone] or Antidepressants like Zoloft [sertraline] or Prozac [Fluoxetine])	₀ ☐ Yes ₁ ☐ No		
Has your child been diagnosed with a condition that influences physical activity or cognition?	₀ ☐ Yes ₁ ☐ No		
Is your child currently enrolled in a formal weight loss program?	₀ ☐ Yes ₁ ☐ No		
Was your child enrolled in a formal weight loss program within the previous 6 months?	₀ ☐ Yes ₁ ☐ No		

Thank you for your time. We have all the information we need from you and we appreciate your interest. Please note that you will be randomly assigned to either the intervention or control group. If you are assigned to the intervention group, you will participate in the intervention. If you are assigned to the control group, you will have the option to participate in the program later in 2021 or 2022. If you are not eligible to participate in this study, your information will be deleted from our data base.

05/30/2021

Subject No.	Date of Screen	Form filled out by:	Data entered by:																
 	<table border="1"> <tr> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> </tr> <tr> <td colspan="2">MM</td> <td colspan="2">DD</td> <td colspan="4">YYYY</td> </tr> </table>									MM		DD		YYYY				 	
MM		DD		YYYY															

The main researcher conducting this study is Dr. Sami Yli-Piipari at the University of Georgia. Please ask any questions you have now. If you have questions later, you may contact Dr. Sami Yli-Piipari at syp@uga.edu or at 706-542-4462. If you have any questions or concerns regarding your rights as a research participant in this study, you may contact the Institutional Review Board (IRB) Chairperson at 706.542.3199 or irb@uga.edu.

Thank you again for your willingness to answer our questions.

Decision Regarding Eligibility:

☐ Yes

☐ No **Determined Ineligible for Participation**

Factor(s) Rendering Them Ineligible: _____

Comments: _____

Date Potential Participant Informed of Ineligibility: _____

05/30/2021

APPENDIX D

DIET RECALL

Participant ID# _____ Visit Date _____

DIRECTIONS FOR KEEPING A 3-DAY DIET DIARY

Please write down everything you eat (meals, snacks, beverages) for three days on these forms. Please select **TWO WEEKDAYS AND ONE WEEKEND DAY**. Use as much space as you need.

1. Write down the date and day at the top of the form.

2. Write down the first foods you ate for that day. Write down:

The time of day you ate the food(s).

Each food that you ate.

How the food was prepared (baked, boiled, fried, microwaved).

How much you ate (cup, 1/2 cup, pieces, tablespoons, teaspoons).

3. It is important to describe each food you eat in detail.

For example:

Write down brand names for each food you ate if you know them.

Write down the type of milk (whole, 2%, or skim) and bread (white, wheat, etc).

Write down if the food was fresh, frozen, or canned.

If you ate a casserole or a salad, write down the foods there were in it and amounts.

If you add things like butter, jelly, sugar, honey, or cream to foods or beverages, please write them down with the amounts used.

4. Do you drink whole _____, 2% _____, 1% _____, or skim _____ milk?

5. Do you use white _____ or whole-wheat _____ bread?

6. What is the complete name and brand name of bread that you eat most often?

7. About how many glasses of water do you drink each day? _____

DAY 1 OF THE DIET DIARY

ID: _____ CHECKED BY: _____

DATE: _____ DAY OF THE WEEK: _____

Did you drink a calcium-fortified beverage today (e.g. Calcium-fortified orange juice) or eat a calcium-fortified food (e.g. Total breakfast cereal)? Yes No

If yes, list all the calcium-fortified beverages/foods, with the BRAND name, and how much:

Write down everything you eat, beginning with the first thing you have for breakfast. Be sure to include very detailed information such as how the food was prepared, how much you ate, and the brand names.

Time Eaten	Foods Eaten	Preparation Methods	Amount (cup, 1/2 cup, piece, etc)

DAY 2 OF THE DIET DIARY

ID: _____ **CHECKED BY:** _____

DATE: _____ **DAY OF THE WEEK:** _____

Did you drink a calcium-fortified beverage today (e.g. Calcium-fortified orange juice) or eat a calcium-fortified food (e.g. Total breakfast cereal)? **Yes** **No**

If yes, list all the calcium-fortified beverages/foods, with the BRAND name, and how much:

Write down everything you eat, beginning with the first thing you have for breakfast. Be sure to include very detailed information such as how the food was prepared, how much you ate, and the brand names.

Time Eaten	Foods Eaten	Preparation Methods	Amount (cup, 1/2 cup, piece, etc)

DAY 3 OF THE DIET DIARY

ID: _____ CHECKED BY: _____

DATE: _____ DAY OF THE WEEK: _____

Did you drink a calcium-fortified beverage today (e.g. Calcium-fortified orange juice) or eat a calcium-fortified food (e.g. Total breakfast cereal)? Yes No

If yes, list all the calcium-fortified beverages/foods, with the BRAND name, and how much:

Write down everything you eat, beginning with the first thing you have for breakfast. Be sure to include very detailed information such as how the food was prepared, how much you ate, and the brand names.

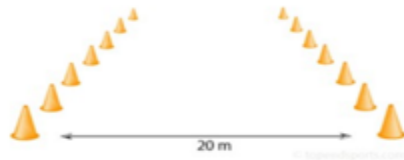
Time Eaten	Foods Eaten	Preparation Methods	Amount (cup, 1/2 cup, piece, etc)

APPENDIX E

FITNESS TEST

Fitness test

20 Meter Pacer Test



P.A.C.E.R. stands for **Progressive Aerobic Cardiovascular Endurance Run**. It is a multi-stage fitness test, performed in a shuttle-run format, that helps children pace themselves effectively, and is generally regarded as more fun for younger children than the mile run because the pace can be set to music. The P.A.C.E.R. is a viable alternative to the mile run, even though both tests measure aerobic endurance, because it can be administered indoors or in a much smaller area than is needed for the mile run.

Cardiovascular Endurance will be measured using the Progressive Aerobic Cardiovascular Endurance Run (PACER) (Plowman & Meredith, 2013). Adhering to the cadence with an increasing pace, participants were asked to run as many 20- meter laps as possible.

The curl-up

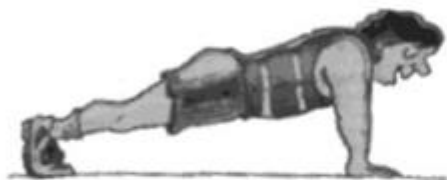


The **curl-up** is a test of abdominal strength and endurance. Strength and endurance of abdominal muscles are important in promoting good posture and correct pelvic alignment, both important elements in good back health. The previous version of the curl-up sometimes caused neck strain and did not account for the differences in the length of arms and legs of growing children. The improved version addresses both of these problems as well as better isolating the abdominal muscles for a more accurate indication of strength and endurance.

The curl-up test will be used to measure participants' abdominal muscular endurance and strength. In a starting position, participants will be asked to lay on their backs with knees bent at 100 degrees, both feet on the floor, with arms straight and parallel to the body, and an 11.4 cm wide measuring tape was situated under participants' legs so that their fingertips were just resting on the nearest edge of the tape. Participants will be asked to curl up so that their fingers slid across the measuring tape until their fingertips reached the other side of tape. The final score will be the number of correctly completed curl-ups.

A push-up test will be used to measure participants' upper body muscular endurance and strength. The final score of the push-up test will be the number of correctly completed push-ups.

The push-up



The **push-up** is a test of upper body muscle strength and endurance. Strength and endurance of the muscles of the upper body are important in activities of daily living, maintaining functional health and promoting good posture.



A push-up test will be used to measure participants' upper body muscular endurance and strength. The final score of the push-up test will be the number of correctly completed push-ups.

APPENDIX F

EXERCISE REGUALTIONS QUESTIONNAIRE

EXERCISE REGULATIONS QUESTIONNAIRE (BREQ-3)

Age: years Sex: male female (please circle)

WHY DO YOU ENGAGE IN EXERCISE?

We are interested in the reasons underlying peoples' decisions to engage or not engage in physical exercise. Using the scale below, please indicate to what extent each of the following items is true for you. Please note that there are no right or wrong answers and no trick questions. We simply want to know how you personally feel about exercise. Your responses will be held in confidence and only used for our research purposes.

		Not true for me		Sometimes true for me		Very true for me
1	It's important to me to exercise regularly	0	1	2	3	4
2	I don't see why I should have to exercise	0	1	2	3	4
3	I exercise because it's fun	0	1	2	3	4
4	I feel guilty when I don't exercise	0	1	2	3	4
5	I exercise because it is consistent with my life goals	0	1	2	3	4
6	I exercise because other people say I should	0	1	2	3	4
7	I value the benefits of exercise	0	1	2	3	4
8	I can't see why I should bother exercising	0	1	2	3	4
9	I enjoy my exercise sessions	0	1	2	3	4
10	I feel ashamed when I miss an exercise session	0	1	2	3	4
11	I consider exercise part of my identity	0	1	2	3	4
12	I take part in exercise because my friends/family/partner say I should	0	1	2	3	4
13	I think it is important to make the effort to exercise regularly	0	1	2	3	4
14	I don't see the point in exercising	0	1	2	3	4
15	I find exercise a pleasurable activity	0	1	2	3	4
16	I feel like a failure when I haven't exercised in a while	0	1	2	3	4
17	I consider exercise a fundamental part of who I am	0	1	2	3	4
18	I exercise because others will not be pleased with me if I don't	0	1	2	3	4
19	I get restless if I don't exercise regularly	0	1	2	3	4
20	I think exercising is a waste of time	0	1	2	3	4

		Not true for me		Sometimes true for me		Very true for me
21	I get pleasure and satisfaction from participating in exercise	0	1	2	3	4
22	I would feel bad about myself if I was not making time to exercise	0	1	2	3	4
23	I consider exercise consistent with my values	0	1	2	3	4
24	I feel under pressure from my friends/family to exercise	0	1	2	3	4

Thank you for taking part in our research

David Markland PhD, C.Psychol
 School of Sport, Health & Exercise Sciences
 University of Wales, Bangor
 d.a.markland@bangor.ac.uk
 October 2014

APPENDIX G

RATINGS OF PERCEIVED EXERTION SCALE

RPE SCALE	RATE OF PERCEIVED EXERTION
10 /	MAX EFFORT ACTIVITY Feels almost impossible to keep going. Completely out of breath, unable to talk. Cannot maintain for more than a very short time
9 /	VERY HARD ACTIVITY Very difficult to maintain exercise intensity. Can barely breathe and speak only a few words
7-8 /	VIGOROUS ACTIVITY Borderline uncomfortable. Short of breath, can speak a sentence
4-6 /	MODERATE ACTIVITY Breathing heavily, can hold a short conversation. Still somewhat comfortable, but becoming noticeably more challenging
2-3 /	LIGHT ACTIVITY Feels like you can maintain for hours. Easy to breathe and carry a conversation
1 /	VERY LIGHT ACTIVITY Hardly any exertion, but more than sleeping, watching TV, etc

APPENDIX H
BACKGROUND QUESTIONNAIRE

Background Questionnaire

Demographic Information

1. Name: _____
2. Date: __/__/2021
3. Gender (circle one): Male Female
4. Age: _____
5. School Grade Level: _____
6. Ethnicity (circle one): Black, White, Asian, Native America, Hispanic,
Other: _____

Thank you very much. Hope you will enjoy the program!!!!

APPENDIX I

SATISFACTION WITH LIFE SCALE QUESTIONNAIRE

Satisfaction With Life Scale-Child (SWLS-C)

For each of the following statements, please circle the number that describes you the best. Please read each sentence carefully and answer honestly. Thank you.

	Disagree a lot	Disagree a little	Don't agree or disagree	Agree a little	Agree a lot
1. In most ways my life is close to the way I would want it to be	1	2	3	4	5
2. The things in my life are excellent	1	2	3	4	5
3. I am happy with my life	1	2	3	4	5
4. So far I have gotten the important things I want in life	1	2	3	4	5
5. If I could live my life over, I would have it the same way	1	2	3	4	5

SCORING: SWLS-C items are scored on a 5-point scale ranging from 1 ("disagree a lot") to 5 ("agree a lot") then added together yielding a total score ranging from 5 to 25.

The official citation that should be used when referencing this material is: Gadermann, A. M., Schonert-Reichl, K. A., & Zumbo, B. D. (2010). Investigating validity evidence of the Satisfaction with Life Scale adapted for Children. *Social Indicators Research*, 96, 229-247.

APPENDIX J

REVISED COCHRANE RISK-OF-BIAS TOOL FOR RANDOMIZED TRIALS

Revised Cochrane risk-of-bias tool for randomized trials (RoB 2) TEMPLATE FOR COMPLETION

Edited by Julian PT Higgins, Jelena Savović, Matthew J Page, Jonathan AC Sterne
on behalf of the RoB2 Development Group

Version of 22 August 2019

The development of the RoB 2 tool was supported by the MRC Network of Hubs for Trials Methodology Research (MR/L004933/2- N61), with the support of the host MRC ConDuCT-II Hub (Collaboration and innovation for Difficult and Complex randomised controlled Trials [In](#) Invasive procedures - MR/K025643/1), by MRC research grant MR/M025209/1, and by a grant from The Cochrane Collaboration.



This work is licensed under a [Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License](https://creativecommons.org/licenses/by-nc-nd/4.0/).

Study details

Reference

Study design

- ☒ Individually-randomized parallel-group trial
- ☐ Cluster-randomized parallel-group trial
- ☐ Individually randomized cross-over (or other matched) trial

For the purposes of this assessment, the interventions being compared are defined as

Experimental: Comparator:

Specify which outcome is being assessed for risk of bias

Specify the numerical result being assessed. In case of multiple alternative analyses being presented, specify the numeric result (e.g. RR = 1.52 (95% CI 0.83 to 2.77) and/or a reference (e.g. to a table, figure or paragraph) that uniquely defines the result being assessed.

Is the review team's aim for this result...?

- ☐ to assess the effect of *assignment to intervention* (the 'intention-to-treat' effect)
- ☐ to assess the effect of *adhering to intervention* (the 'per-protocol' effect)

If the aim is to assess the effect of *adhering to intervention*, select the deviations from intended intervention that should be addressed (at least one must be checked):

- ☐ occurrence of non-protocol interventions
- ☐ failures in implementing the intervention that could have affected the outcome
- ☐ non-adherence to their assigned intervention by trial participants

Which of the following sources were obtained to help inform the risk-of-bias assessment? (tick as many as apply)

- ☐ Journal article(s) with results of the trial
- ☐ Trial protocol
- ☐ Statistical analysis plan (SAP)
- ☐ Non-commercial trial registry record (e.g. ClinicalTrials.gov record)
- ☐ Company-owned trial registry record (e.g. GSK Clinical Study Register record)
- ☐ "Grey literature" (e.g. unpublished thesis)
- ☐ Conference abstract(s) about the trial
- ☐ Regulatory document (e.g. Clinical Study Report, Drug Approval Package)
- ☐ Research ethics application
- ☐ Grant database summary (e.g. NIH RePORTER or Research Councils UK Gateway to Research)
- ☐ Personal communication with trialist
- ☐ Personal communication with the sponsor

Risk of bias assessment

Responses underlined in green are potential markers for low risk of bias, and responses in **red** are potential markers for a risk of bias. Where questions relate only to sign posts to other questions, no formatting is used.

Domain 1: Risk of bias arising from the randomization process

Signalling questions	Comments	Response options
1.1 Was the allocation sequence random?		Y / PY / PN / N / NI
1.2 Was the allocation sequence concealed until participants were enrolled and assigned to interventions?		Y / PY / PN / N / NI
1.3 Did baseline differences between intervention groups suggest a problem with the randomization process?		Y / PY / PN / N / NI
Risk-of-bias judgement		Low / High / Some concerns
Optional: What is the predicted direction of bias arising from the randomization process?		NA / Favours experimental / Favours comparator / Towards null / Away from null / Unpredictable

Domain 2: Risk of bias due to deviations from the intended interventions (*effect of assignment to intervention*)

Signalling questions	Comments	Response options
2.1. Were participants aware of their assigned intervention during the trial?		Y / PY / PN / N / NI
2.2. Were carers and people delivering the interventions aware of participants' assigned intervention during the trial?		Y / PY / PN / N / NI
2.3. If Y/PY/NI to 2.1 or 2.2: Were there deviations from the intended intervention that arose because of the trial context?		NA / Y / PY / PN / N / NI
2.4 If Y/PY to 2.3: Were these deviations likely to have affected the outcome?		NA / Y / PY / PN / N / NI
2.5. If Y/PY/NI to 2.4: Were these deviations from intended intervention balanced between groups?		NA / Y / PY / PN / N / NI
2.6 Was an appropriate analysis used to estimate the effect of assignment to intervention?		Y / PY / PN / N / NI
2.7 If N/PN/NI to 2.6: Was there potential for a substantial impact (on the result) of the failure to analyse participants in the group to which they were randomized?		NA / Y / PY / PN / N / NI
Risk-of-bias judgement		Low / High / Some concerns
Optional: What is the predicted direction of bias due to deviations from intended interventions?		NA / Favours experimental / Favours comparator / Towards null / Away from null / Unpredictable

Domain 3: Missing outcome data

Signalling questions	Comments	Response options
3.1 Were data for this outcome available for all, or nearly all, participants randomized?		Y / PY / PN / N / NI
3.2 If N/PN/NI to 3.1: Is there evidence that the result was not biased by missing outcome data?		NA / Y / PY / PN / N
3.3 If N/PN to 3.2: Could missingness in the outcome depend on its true value?		NA / Y / PY / PN / N / NI
3.4 If Y/PY/NI to 3.3: Is it likely that missingness in the outcome depended on its true value?		NA / Y / PY / PN / N / NI
Risk-of-bias judgement		Low / High / Some concerns
Optional: What is the predicted direction of bias due to missing outcome data?		NA / Favours experimental / Favours comparator / Towards null / Away from null / Unpredictable

Domain 4: Risk of bias in measurement of the outcome

Signalling questions	Comments	Response options
4.1 Was the method of measuring the outcome inappropriate?		Y / PY / PN / N / NI
4.2 Could measurement or ascertainment of the outcome have differed between intervention groups?		Y / PY / PN / N / NI
4.3 If N/PN/NI to 4.1 and 4.2: Were outcome assessors aware of the intervention received by study participants?		NA / Y / PY / PN / N / NI
4.4 If Y/PY/NI to 4.3: Could assessment of the outcome have been influenced by knowledge of intervention received?		NA / Y / PY / PN / N / NI
4.5 If Y/PY/NI to 4.4: Is it likely that assessment of the outcome was influenced by knowledge of intervention received?		NA / Y / PY / PN / N / NI
Risk-of-bias judgement		Low / High / Some concerns
Optional: What is the predicted direction of bias in measurement of the outcome?		NA / Favours experimental / Favours comparator / Towards null / Away from null / Unpredictable

Domain 5: Risk of bias in selection of the reported result

Signalling questions	Comments	Response options
5.1 Were the data that produced this result analysed in accordance with a pre-specified analysis plan that was finalized before unblinded outcome data were available for analysis?		Y / PY / PN / N / NI
Is the numerical result being assessed likely to have been selected, on the basis of the results, from...		
5.2. ... multiple eligible outcome measurements (e.g. scales, definitions, time points) within the outcome domain?		Y / PY / PN / N / NI
5.3 ... multiple eligible analyses of the data?		Y / PY / PN / N / NI
Risk-of-bias judgement		Low / High / Some concerns
Optional: What is the predicted direction of bias due to selection of the reported result?		NA / Favours experimental / Favours comparator / Towards null / Away from null / Unpredictable