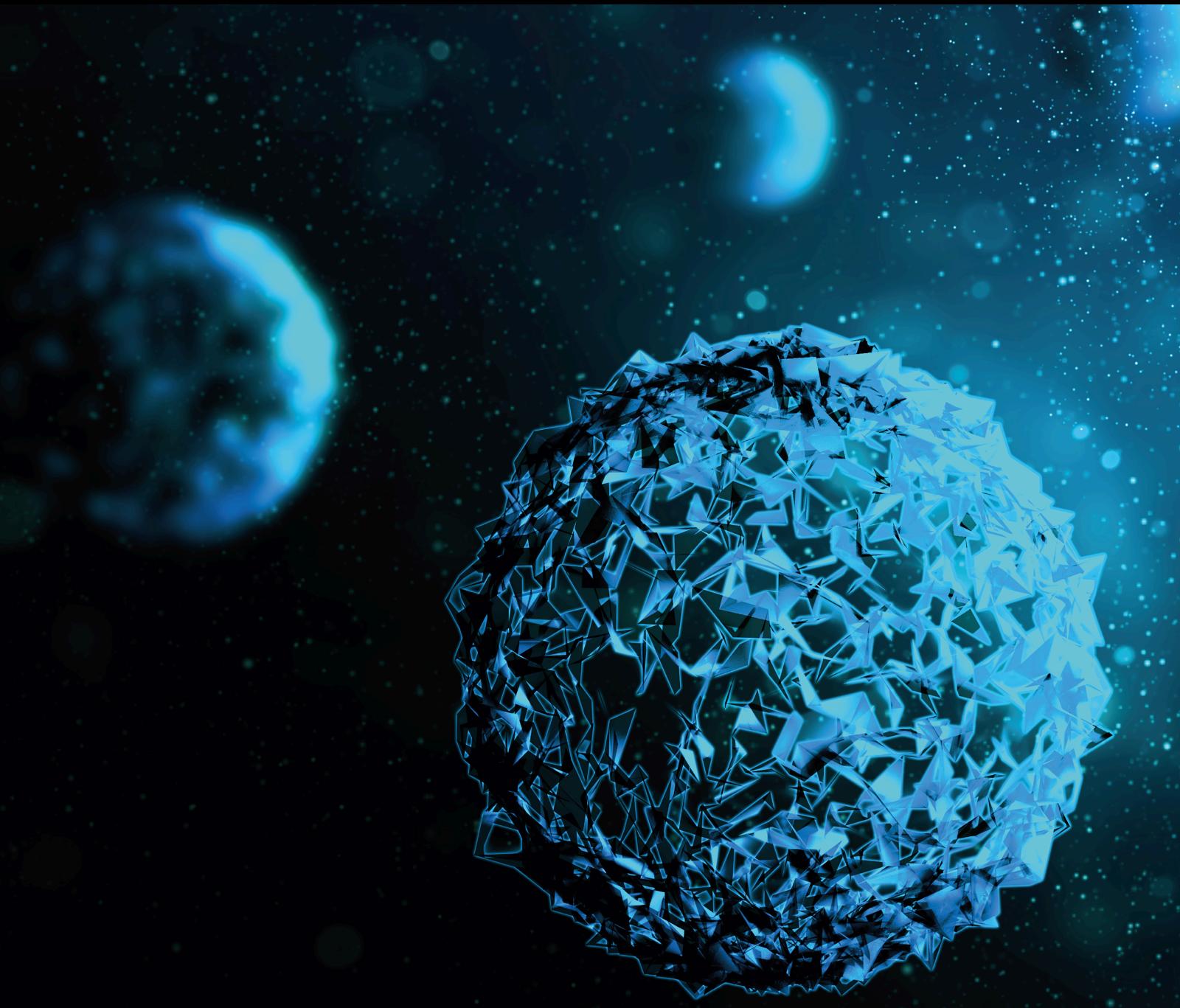


# Physical Activity, Mental Health and Well-Being across Lifespan

Lead Guest Editor: Weiyun Chen

Guest Editors: Ali Khani Jeihooni, Xiangli Gu, and Haichun Sun





---

# **Physical Activity, Mental Health and Well-Being across Lifespan**

BioMed Research International

---

## **Physical Activity, Mental Health and Well-Being across Lifespan**

Lead Guest Editor: Weiyun Chen

Guest Editors: Ali Khani Jeihooni, Xiangli Gu, and Haichun Sun



Copyright © 2021 Hindawi Limited. All rights reserved.

This is a special issue published in “BioMed Research International.” All articles are open access articles distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.



## Section Editors

Penny A. Asbell, USA  
David Bernardo , Spain  
Gerald Brandacher, USA  
Kim Bridle , Australia  
Laura Chronopoulou , Italy  
Gerald A. Colvin , USA  
Aaron S. Dumont, USA  
Pierfrancesco Franco , Italy  
Raj P. Kandpal , USA  
Fabrizio Montecucco , Italy  
Mangesh S. Pednekar , India  
Letterio S. Politi , USA  
Jinsong Ren , China  
William B. Rodgers, USA  
Harry W. Schroeder , USA  
Andrea Scribante , Italy  
Germán Vicente-Rodriguez , Spain  
Momiao Xiong , USA  
Hui Zhang , China

## Academic Editors









### Public Health

Mauro Henrique Nogueira Guimarães  
Abreu , Brazil  
Italo F. Angelillo , Italy  
Syed Khurram Azmat , Canada  
Arpita Basu , USA  
Shahrazad Bazargan-Hejazi , USA  
Vance W. Berger, USA  
Li-Wei Chou , Taiwan  
Matteo Curcuruto , United Kingdom  
Peter P. Egeghy , USA  
Geng-Feng Fu , China  
Badicu Georgian , Romania  
Bishwajit Ghose , Togo  
Gabriele Giorgi, Italy  
Gianpiero Greco , Italy  
Nguyen Thi Ngoc Han , Vietnam  
Kumud K. Kafle, Nepal

Anna Karakatsani , Greece  
Young-Eun Kim , Republic of Korea  
Barthélémy Kuate Defo, Canada  
Blanca Laffon , Spain  
Barbara Loera, Italy  
Shivakumar M.S., India  
Andrea Maugeri , Italy  
Dominique J. Monlezun , USA  
Agnese Maria Chiara Rapisarda, Italy  
Venerando Rapisarda , Italy  
Babar Tasneem Shaikh , Pakistan  
Hossain U. Shekhar , Bangladesh  
Ritu Singh , India  
Sunghee H. Tak , Republic of Korea  
Tomas Tesar , Slovakia  
Antonio Vitarelli , Italy  
Solomon Yimer , Ethiopia

## Contents

### **Mediating Effect of Motor Competence on the Relationship between Physical Activity and Quality of Life in Children with Attention Deficit Hyperactivity Disorder**

Ru Li , Xiao Liang , Fang Liu , Ziwei Zhou , Zhenzhen Zhang , Yongshen Lu , Peng Wang , and Binrang Yang 

Research Article (12 pages), Article ID 4814250, Volume 2021 (2021)

### **Feasibility and Effectiveness of the Web-Based WeActive and WeMindful Interventions on Physical Activity and Psychological Well-Being**

Michele W. Marenus , Andy Murray , Kathryn Friedman, Julia Sanowski, Haley Ottensoser, Ana Cahuas, Varun Kumaravel, and Weiyun Chen 

Research Article (11 pages), Article ID 8400241, Volume 2021 (2021)

### **Assessment Methods of Body Fat in Recreational Marathon Runners: Bioelectrical Impedance Analysis versus Skinfold Thickness**

Pantelis T. Nikolaidis , Rodrigo Luiz Vancini , Marília dos Santos Andrade , Claudio Andre Barbosa de Lira , and Beat Knechtle 

Research Article (6 pages), Article ID 3717562, Volume 2021 (2021)

### **Intensity-Modified Recreational Volleyball Training Improves Health Markers and Physical Fitness in 25–55-Year-Old Men**

Goran Vasić , Nebojša Trajković , Draženka Mačak , Tine Sattler, Peter Krstrup , Nikola Starčević, Goran Sporiš , and Špela Bogataj 

Research Article (9 pages), Article ID 9938344, Volume 2021 (2021)

## Research Article

# Mediating Effect of Motor Competence on the Relationship between Physical Activity and Quality of Life in Children with Attention Deficit Hyperactivity Disorder

Ru Li <sup>1</sup>, Xiao Liang <sup>2</sup>, Fang Liu <sup>1</sup>, Ziwei Zhou <sup>1</sup>, Zhenzhen Zhang <sup>1</sup>, Yongshen Lu <sup>1</sup>, Peng Wang <sup>3</sup>, and Binrang Yang <sup>4</sup>

<sup>1</sup>Faculty of Physical Education, Shenzhen University, Shenzhen, China

<sup>2</sup>Department of Sports Science and Physical Education, The Chinese University of Hong Kong, Hong Kong, China

<sup>3</sup>Cardiac Rehabilitation Center, Fuwai Hospital, CAMS & PUMC, Beijing, China

<sup>4</sup>Shenzhen Children's Hospital, Shenzhen, China

Correspondence should be addressed to Binrang Yang; [ybinrang@163.com](mailto:ybinrang@163.com)

Received 3 July 2021; Revised 30 September 2021; Accepted 29 November 2021; Published 24 December 2021

Academic Editor: Xiangli Gu

Copyright © 2021 Ru Li et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

This study examined the mediating role of motor competence in the association between physical activity (PA) and quality of life (QoL) and the moderating role of age in the indirect relationship between PA and QoL in children with ADHD. Eighty-six children aged 6–12 years old ( $M$  age = 8.45,  $SD$  = 1.40, 17.4% girls) with the diagnosis of ADHD were recruited in this study. Participants wore a wGT3X-BT accelerometer on their wrist for seven consecutive days to measure PA. Motor competence was measured by the Test of Gross Motor Development-Third Edition (TGMD-3). Quality of life (QoL) was assessed by the parent-reported Chinese version of the Pediatric Quality of Life Inventory. MVPA was positively associated with object control skills but was not directly related to QoL. Using the bootstrapping method, the indirect effect of object control was found between MVPA and social functioning (0.10, 95%CI = [0.01, 0.21]), school functioning (0.09, 95%CI = [0.01, 0.18]), and overall QoL (0.07, 95%CI = [0.01, 0.16]), supporting the full mediation effect. Moderated mediation analysis further revealed that age strengthened the indirect effect from MVPA to social and school functioning via object control. Findings of this study indicated that MVPA is positively associated with object control skills, which in turn, is related to psychological aspects of QoL in children with ADHD. Age was found to moderate the indirect mediation paths. The findings may inform future expeditions on designing an effective intervention that helps to improve MC and QoL in children with ADHD.

## 1. Introduction

Attention deficit hyperactivity disorder (ADHD) is a prevalent neurodevelopmental disorder characterized by age-inappropriate inattention, impulsivity, and hyperactivity [1] that affects around 2.2%–7.2% of school age children worldwide [2]. Males are more commonly diagnosed with ADHD in children and adolescents, with the gender ratio ranging from 2:1 to 10:1 [3, 4]. Higher male-to-female ratios were observed in clinical versus population-based samples [5]. The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) characterizes ADHD by three different subtypes, including predominantly hyperactive-impulsive subtype

(ADHD-HI), predominantly inattentive subtype (ADHD-I), and a combined subtype (ADHD-C) [1]. Although ADHD is commonly diagnosed in childhood, the symptoms may maintain throughout adolescence and persist into adulthood in up to 70% of children with ADHD [6], which may produce negative consequences on their daily routine quality of life (QoL).

There is a growing realization that psychiatric comorbidity is the “rule rather than the exception” ([7], p. 1543) for children with ADHD. ADHD may experience significant difficulties that go beyond the core symptoms of ADHD in social incompetence, sleep problems, academic underachievement, poor motor proficiency, and executive dysfunction [8–12]. These

negative outcomes may imply substantial deficits in various aspects of QoL, directly impairing physical and psychosocial well-being of children with ADHD. It is estimated that 50% of individuals with ADHD manifest developmental coordination disorder (DCD) in comparison with approximately 2-6% of the general population [13, 14]. A growing body of evidence supports the notion that children with DCD have lower overall health-related QoL compared to healthy counterparts [15–17]. According to the World Health Organization, QoL is defined as “an individual’s perception of their position in life in the context of the culture and value systems in which they live and to their goals, expectations, standards and concerns” ([18], p. 1405). Specifically, QoL reflects one’s subjective perception of the influence of life situation, including disease and treatment, on physical, psychological, and social functioning [19, 20]. QoL has become a major focus of outcome measures in child and adolescent health studies, particularly for those with developmental disorders who are vulnerable to physical and mental problems. There is emerging evidence showing that children with ADHD reported lower level of QoL compared with their typically developing (TD) peers [21]. Particularly, ADHD severely compromises children’s physical functioning, psychosocial health, and general life quality, with increased symptom level resulting in worse QoL [20, 22]. There has been little discussion about the factors that are associated with QoL in children with ADHD [13]. Thus, it is imperative to understand the antecedents and potential mediators or moderators of various domains of QoL that may inform educators and healthcare to design effective interventions benefiting QoL.

Physical activity (PA) was observed to be positively related to a range of physical and mental health outcomes in youth [23]. Past reviews generally reported a significant positive association between PA and QoL in youth (Hedges’  $g = 0.302$ ) [24]. Specifically, moderate-to-vigorous PA (MVPA) is strongly correlated with QoL in children, implying that physically active children may experience improvement in QoL [25]. The latest WHO Guidelines on Physical Activity and Sedentary Behaviours recommends that children and adolescents living with disability should engage in at least 60 minutes of MVPA daily, including children and adolescents with ADHD [26]. Unfortunately, previous research measuring PA in children with ADHD have proven that they could not meet the minimum recommended criteria of 60 mins/day in MVPA [27, 28]. One recent study found that children with ADHD who engaged in increased amounts of PA reported higher QoL scores than those who were less physically active and sedentary [29]. It seems that increased time spent in MVPA may be a potential antecedent factor contributing to improved QoL in children with ADHD; however, the underlying mechanisms regarding possible mediators or moderators between PA and QoL in children with ADHD have not been established.

Motor competence (MC) refers to the degree of motor proficiency in performing fundamental movement skills (FMS) including both locomotor (e.g., jumping) and object control (e.g., catching) skills [30]. FMS competency is indispensable for children to master daily activities, which is

commonly regarded as the essential building blocks for developing senior lifetime movement and context-specific motor skills from childhood to adulthood [31]. The fact is that motor impairments occur frequently in 30-40% children with neurodevelopmental disorders [10]. Specific fine and gross motor difficulties were observed in children with ADHD [32]. The relationship between MC and PA participation has gained strong empirical support, and several studies have proposed their bidirectional associations in TD children. For example, greater motor proficiency in youth may predict MVPA participation and health throughout lifespan [33]; reversely, increased PA may enhance the level of mastery of motor skills [34]. Nevertheless, there is a paucity of evidence supporting the direct link between PA and MC in children with ADHD. Intervention studies indicated that physical activity intervention had positive effect on motor proficiency in children with ADHD [35, 36].

Additionally, poor MC was found to be connected with impaired psychosocial health in children [37]. A recent study showed that children with higher gross motor competence scores perceived higher health-related QoL [38]. Based on the conceptual model proposed by Blair [39], health-related behaviors (e.g., PA, diet, and alcohol consumption) influence various components of fitness (e.g., muscular, cardiorespiratory, motor, and metabolic components), which in turn, affect health-related outcomes. Theoretically, it is reasonable to assume the indirect association between PA and health-related QoL through the mediation of motor components of fitness. Therefore, it could be speculated that higher levels of MVPA were related to greater performance on MC, which, in turn, was associated with better QoL in children. Causalities among these variables were not established, leaving unclear whether MC could be considered as outcome of MVPA and antecedent factor predicting QoL. Stodden et al. [40] presented a theoretical framework where PA and MC exhibited varied bidirectional associations from early to middle childhood. In alignment with this theoretical framework, Lima et al. [41] found reciprocal longitudinal relationship between PA and MC and further implied that the strength of their changes across childhood and adolescence. Furthermore, age was assumed to be a potential moderator in the link between PA and MC as another longitudinal study found that children at young age (2-6 years old) demonstrated diverse levels of PA and MC that were unrelated and suggested the relationship between PA and MC evolves as children age [42]. One previous review found that age was negatively associated with QoL in children and adolescents with ADHD [20]. To date, no previous studies examined whether age as a moderator in the indirect relation between MVPA and QoL via MC. In this context, exploring the potential antecedents of, and pathways for, improved QoL in children with ADHD is of paramount importance.

The purpose of this study was twofold: (a) to investigate whether MC would mediate the association between MVPA and different domains of QoL in children with ADHD and (b) to test whether the direct and indirect relations between MVPA and QoL via MC were moderated by age. The proposed model is illustrated in Figure 1.

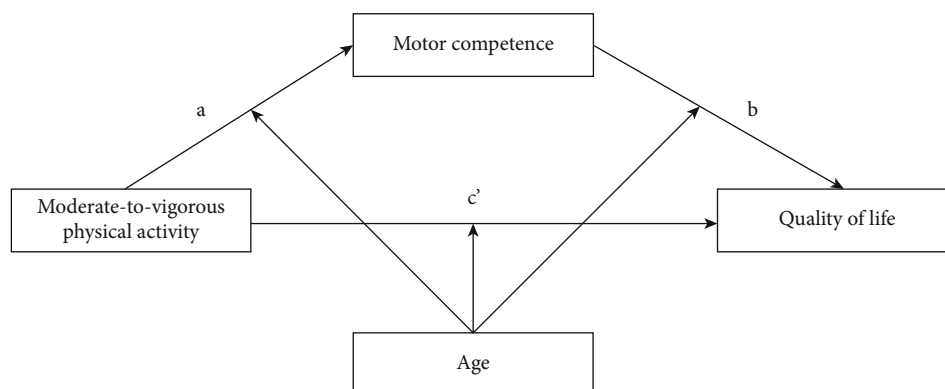


FIGURE 1: The proposed moderated mediation model.

## 2. Materials and Methods

**2.1. Participants.** Children aged 6-12 years old were recruited from the outpatient clinics of Children's Healthcare & Mental Health Center at Shenzhen Children's Hospital. Inclusion criteria include (1) ADHD diagnoses based on the criteria of DSM-5 [1], (2) having a full IQ of more than 70 measured by the Chinese Wechsler Intelligence Scale for Children, fourth edition [43], (3) having no comorbid axis-I psychiatric disorders or a history of major neurological diseases, and (4) having no other medical conditions that limited their physical activity capacities (e.g., asthma and cardiac disease). A total of 86 medication-naïve patients with ADHD were recruited, and their diagnoses were confirmed by two experienced psychiatrists who utilized the standard structured interview according to the Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and lifetime Version [44, 45]. All participants were full-time students enrolled in regular schools. Table 1 describes the characteristics of the participants.

### 2.2. Measures

**2.2.1. Physical Activity.** Physical activity data used for analysis were time spent in MVPA, which was objectively measured by asking the participants to wear the Actigraph wGT3X-BT accelerometer device. Children were required to wear the devices on the nondominant wrist for seven consecutive days and were instructed to only take it off when they were taking baths or swimming. Sampling rate was set to 60 Hz. Data in raw format as GT3X file was converted to raw csv file format for signal processing in R using GGIR package version 2.4-0 [46]. Signal processing in GGIR involves the detection of nonwear time and the calculation of the average magnitude of dynamic acceleration corrected for gravity (ENMO). A valid day was defined as accelerometer wearing for 100% during the daytime. Participants were excluded if they were of less than four valid days of wear. The MVPA cut point was classified as 100 mg (MVPA threshold parameter =  $c(100)$ ), which had been validated for wrist wearing in children [47]. MVPA values were computed by averaging MVPA metrics of all valid days for each participant.

**2.2.2. Motor Competence.** The motor competence was assessed based on the standardized protocols described in the Test of Gross Motor Development-Third Edition [48]. The TGMD-3 has been validated in China with satisfied reliability, which provides an objective instrument evaluating basic motor skills for Chinese children [49]. It assesses the performance of six locomotor and seven object control skills with a total raw score of 100. In accordance with previous study [50], three locomotion tasks (i.e., running, skipping, and jumping) and three ball skill tasks (i.e., catching, overhand throw, and underhand throw) were selected to represent locomotion and object control capacities, respectively. Before the assessment of each skill, a trained researcher first demonstrated the skill, and the participants were allowed one practice trial. Then, the participants performed two formal trials that were observed and coded by an experienced rater. Six fundamental movement skills of all participants were individually videotaped using an iPad for later analysis by another rater. The two independent raters were trained, and they had to exceed an interrater agreement (IOA) score of 85% before conducting formal assessments. Each skill was assessed based on 3-5 performance criteria that are scored 1 point (present) or 0 point (absent) using process-oriented checklists. The scores rated from two attempts of each skill were summed to produce a total score of locomotion and object control. The two independent raters evaluated all trials of each skill. The interrater agreement was strong ( $ICC = 0.88$ ,  $95\%CI = [0.68, 0.95]$ ). The disagreement between the two raters was discussed and reassessed to decide the final score.

**2.2.3. Quality of Life.** The 23-item Pediatric Quality of Life Inventory (PedsQLTM Generic Core Scales) [51] was used to assess health-related QoL in children and adolescents aged 2-18 years old. The Standard Versions of Parent Proxy-report for Young Child (5-7 years of age) and Child (8-12 years of age) were used considering different age groups of the participants. The PedsQL includes four subscales (physical, emotional, social, and school), of which physical health summary score was computed by averaging 8 items of physical functioning (same as the physical functioning scale), and the psychological health summary score was computed by averaging 15 items of emotional, social,



TABLE 1: Participants' characteristics.

Characteristics	N = 86 mean (SD)
Age	8.45 (1.40)
Gender (boys/girls)	71/15
Height (cm)	131.46 (9.40)
Weight (kg)	29.56 (8.98)
BMI	16.77 (3.00)
ADHD subtype	
Inattention (%)	51 (59.3%)
Hyperactivity (%)	5 (5.8%)
Combined (%)	30 (34.9%)
Comorbidities	
Oppositional defiant disorder (%)	17 (19.8%)
Obsessive compulsive disorder (%)	2 (2.3%)
Tourette syndrome (%)	5 (5.8%)
Enuresis (%)	3 (3.5%)
Encopresis (%)	1 (1.2%)

and school functioning subscales. Parent proxy-reported scores were collected in this study. Scores range from 0 to 100, with higher scores suggesting better QoL. This study used the Chinese version of the PedsQLTM Core (Standard), which has been psychometrically evaluated and well validated [52]. The internal consistency of each subscale was reported to be acceptable in this study (physical :  $\alpha = 0.82$ ; emotional :  $\alpha = 0.77$ ; social :  $\alpha = 0.86$ ; school:  $\alpha = 0.73$ ).

**2.2.4. Confounders.** For testing that meditation effect of MC between MVPA and QoL, confounders included children's age, gender, and BMI; ADHD subtype (ADHD-I, ADHD-C, and ADHD-HI); and ADHD symptom severity assessed by Chinese version of the Swanson, Nolan, and Pelham Version IV Scale-parent form (SNAP-IV [53]).

**2.3. Procedure.** This study was approved by the research ethics committees of Shenzhen Children's Hospital, Shenzhen, China (Approval ID: 202010302). Informed consent form was obtained from parents in accordance with the Declaration of Helsinki. Participants visited the lab twice individually with their parents. For the first time, their weight and height were measured, and body mass index (BMI) was calculated by dividing body mass (kg) by stature squared ( $m^2$ ). Subsequently, they finished the TGMD-3 before they were provided the accelerometer. Their parents completed the questionnaire of PedsQL and SNAP-IV. The participants visited the lab again to return the accelerometer after wearing it for seven days.

**2.4. Data Analysis.** Descriptive statistics were calculated for MVPA, motor competence score, and QoL. Bivariate correlations among the variables were calculated. The mediating and moderating effects were analyzed using bootstrapping regression models with PROCESS function of bruceR package 0.7.0 in R [54]. PROCESS models developed by Hayes [55] were applied to test the mediating effect of motor com-

petence as well as the moderating effect of age on the direct and indirect links between MVPA and QoL after controlling for potential confounders (i.e., gender, BMI, ADHD subtype, and ADHD symptom severity). All continuous variables were mean centered, and bootstrapping confidence intervals (CIs) utilizing 5000 resamples were used for model estimations.

### 3. Results

**3.1. Preliminary Analyses.** Missing data was absent for each variable. All participants had valid accelerometry data of at least four days. Descriptive statistics, skewness, kurtosis, and correlations among the study variables are demonstrated in Table 2. The data was examined for normality of distribution by skewness ( $|\text{skewness}| < 3$ ) and kurtosis ( $|\text{kurtosis}| < 10$ ) [56]. MVPA was significantly associated with object control skills, but was not directly associated with all dimensions of QoL. Object control was positively associated with social functioning, school functioning, and total score of QoL.

**3.2. Testing for Mediation Effect.** PROCESS model 4 developed by Hayes [55] was used to test the mediation effect of motor skills (locomotion, object control) between MVPA and QoL. The structure and the results of the model applied are reported below. MVPA was the focal predictor ( $F$ ), MC (object control, locomotion) was the proposed mediator ( $M$ ), and age, gender, BMI, ADHD subtype, and ADHD severity were the covariates ( $C$ ).  $F$ ,  $M$ , and  $C$  were included as predictors in a bootstrapping regression analysis predicting the QoL. The following model was tested for each dimension of QoL:

$$\begin{aligned} \text{QoL} = & a + b_1 \text{age} + b_2 \text{gender} + b_3 \text{BMI} \\ & + b_4 \text{ADHD subtype} + b_5 \text{ADHD severity} \\ & + b_6 \text{MVPA} + b_7 \text{MC} \end{aligned} \quad (1)$$

The regression results showed that only object control mediates the relation between MVPA and quality of life. Specifically, MVPA was positively related to object control, which was, in turn, positively associated with social functioning, school functioning, and total score of QoL, respectively. The mediation effects of locomotion between MVPA and various domains of QoL were not found. Table 3 displays the path coefficients of the mediation effects. These results support that object control fully mediated the association between MVPA and social functioning, school functioning, and overall QoL, and the mediation effect accounted for 15%-22% of the total effect of MVPA on these outcomes. The regression results for significant mediation effects were reported in Table 4.

**3.3. Moderated Mediation Effect.** PROCESS model 59 developed by Hayes [55] was used to further examine the direct and indirect relationships between MVPA and QoL via object control moderated by age. The analysis equation changed as follows:

TABLE 2: Descriptive statistics and bivariate correlations.

Variable	M	SD	Skewness	Kurtosis	1	2	3	4	5	6	7	8	9	10
1. MVPA	85.17	30.52	0.29	-0.19	—									
2. Locomotion	14.21	3.33	-0.53	-0.42	0.16	—								
3. Object control	13.08	3.09	-0.22	0.16	0.25*	0.43**	—							
4. TGMD total	27.29	5.35	-0.20	-0.57	0.29*	0.85**	0.84*	—						
5. pH	70.28	17.16	-0.48	0.18	-0.10	0.10	0.16	0.10	—					
6. EF	65.64	17.27	0.10	-0.87	-0.06	-0.07	-0.04	-0.06	0.39**	—				
7. SF	67.91	18.32	-0.00	-0.79	-0.08	0.03	0.28*	0.18	0.53**	0.39**	—			
8. SCF	50.14	13.74	0.47	0.58	-0.06	0.01	0.26*	0.19	0.55**	0.41**	0.56**	—		
9. PSY	61.23	13.27	0.22	0.07	-0.05	0.03	0.20	0.12	0.61**	0.77**	0.83**	0.79**	—	
10. QoL	63.60	12.92	-0.17	-0.46	-0.06	0.01	0.22*	0.12	0.86**	0.68**	0.78**	0.76**	0.93**	—

Note. \* $p < 0.05$ ; \*\* $p < 0.01$ . MVPA: moderate-to-vigorous physical activity; TGMD: test of gross motor development; pH: physical health summary; EF: emotion functioning; SF: social functioning; SCF: school functioning; PSY: psychological health summary; QoL: quality of life.

TABLE 3: Bootstrap analysis summary showing the indirect effects of MVPA on QoL via object control and locomotion.

Path	$a$ path coefficient	$b$ path coefficient	$c'$ path coefficient (direct effect)	Indirect effect ( $a \times b$ )			
				Point estimate	SE	Z	Boot 95% CI
MVPA-OC-PH	0.31**	0.20	-0.07	0.06	0.04	1.69	[-0.01, 0.14]
MVPA-OC-EF	0.31**	-0.05	0.04	-0.01	0.04	-0.36	[-0.10, 0.06]
MVPA-OC-SF	0.31**	0.31**	-0.05	0.10	0.05	1.88	[0.01, 0.21]*
MVPA-OC-SCF	0.31**	0.28*	-0.05	0.09	0.04	1.97	[0.01, 0.18]*
MVPA-OC-PSY	0.31**	0.22	-0.03	0.07	0.04	1.57	[-0.01, 0.16]
MVPA-OC-QOL	0.31**	0.24*	-0.05	0.07	0.04	1.78	[0.01, 0.16]*
MVPA-LM-PH	0.27*	0.01	-0.01	0.01	0.04	0.01	[-0.08, 0.08]
MVPA-LM-EF	0.27*	-0.06	0.04	-0.02	0.04	-0.45	[-0.11, 0.04]
MVPA-LM-SF	0.27*	-0.02	0.05	-0.01	0.03	-0.13	[-0.08, 0.06]
MVPA-LM-SCF	0.27*	0.02	0.03	0.01	0.04	0.14	[-0.09, 0.07]
MVPA-LM-PSY	0.27*	-0.03	0.05	-0.01	0.04	-0.28	[-0.10, 0.05]
MVPA-LM-QOL	0.27*	-0.02	0.03	-0.01	0.04	-0.13	[-0.09, 0.06]

Note. \* $p < .05$ ; \*\* $p < .01$ . Standardized path coefficients are presented. MVPA: moderate-to-vigorous physical activity; OC: object control; LM: locomotion; PH: physical health summary; EF: emotional functioning; SF: social functioning; SCF: school functioning; PSY: psychological health summary; QOL: quality of life.

$$\begin{aligned} \text{QoL} = & a + b_1 \text{ gender} + b_2 \text{ BMI} + b_3 \text{ ADHD subtype} \\ & + b_4 \text{ ADHD severity} + b_5 \text{ age} + b_6 \text{ MVPA} \\ & + b_7 [\text{MVPA} \times \text{age}] + b_8 \text{ MC} + b_9 [\text{MC} \times \text{age}] \end{aligned} \tag{2}$$

With age as a moderator in the regression model, the indirect effect on overall QoL turns to be nonsignificant. The results of parameters for social and school functioning are shown in Table 5. Model 1 of Table 5 shows that the interaction effects (product) of MVPA and age had a significant positive association with object control ( $F = 7.91, p = .006$ ). Simple slope test demonstrated that MVPA was positively associated with object control for older children with ADHD ( $b_{\text{simple}} = 0.06, p < .001$ ), while MVPA yielded a nonsignificant association with object control for younger children with ADHD ( $b_{\text{simple}} = -0.01, p = .86$ ). Simple slope tests demonstrated that age moderated the relation between

MVPA and object control; with the older age of the children, the stronger association between MVPA and object control was reported. Figure 2 shows a clear demonstration of the moderating role of age, separately for different age groups (one SD below and one SD above the mean, respectively). It means that stronger association between MVPA and object control was reported in children aged one SD above the mean (9.85 years) compared to those aged one SD below the mean (7.05 years). Additionally, model 2 of Table 5 illustrated there was a significant main effect of object control on social and school functioning, but these effects were not moderated by age (all  $p > .05$ ). Similarly, age did not significantly moderate the association between MVPA and social and school functioning (all  $p > .05$ ). The bias-corrected percentile bootstrap analysis further indicated that the indirect effect of MVPA on social and school functioning via object control was moderated by



TABLE 4: Testing the mediation effect of object control on quality of life.

(a)

Predictors	Model 1 (SF)			Model 2 (object control)			Model 3 (SF)		
	Standardized coefficient	Unstandardized coefficient	SE	Standardized coefficient	Unstandardized coefficient	SE	Standardized coefficient	Unstandardized coefficient	SE
Age	0.07	0.86	1.50	0.37**	0.87**	0.26	-0.05	-0.62	1.54
Gender	-0.14	-6.70	5.36	-0.20	-1.72	0.90	-0.08	-3.86	5.30
BMI	-0.14	-0.82	0.68	0.11	0.12	0.12	-0.17	-1.01	0.66
ADHD subtype	0.09	1.80	2.18	0.06	0.21	0.37	0.08	1.44	2.10
ADHD severity	-0.40**	-0.86**	0.26	-0.14	-0.06	0.04	-0.36	-0.77**	0.25
MVPA	0.04	0.02	0.07	0.31**	0.03**	0.01	-0.05	-0.03	0.07
Object control							0.31**	1.70*	0.63
R <sup>2</sup>		0.15			0.24			0.22	

(b)

Predictors	Model 1 (SCF)			Model 2 (object control)			Model 3 (SCF)		
	Standardized coefficient	Unstandardized coefficient	SE	Standardized coefficient	Unstandardized coefficient	SE	Standardized coefficient	Unstandardized coefficient	SE
Age	0.08	0.77	1.11	0.37**	0.87**	0.26	-0.02	-0.20	1.15
Gender	0.06	1.91	3.98	-0.20	-1.72	0.90	0.12	4.04	3.93
BMI	-0.07	-0.29	0.51	0.11	0.12	0.12	-0.10	-0.42	0.50
ADHD subtype	0.06	0.82	1.62	0.06	0.21	0.37	0.04	0.58	1.58
ADHD severity	-0.31*	-0.48*	0.19	-0.14	-0.06	0.04	-0.27*	-0.42*	0.19
MVPA	0.04	0.02	0.05	0.31**	0.03**	0.01	-0.05	-0.02	0.05
Object control							0.28*	1.12*	0.47
R <sup>2</sup>		0.09			0.24			0.15	

(c)

Predictors	Model 1 (QOL)			Model 2 (object control)			Model 3 (QOL)		
	Standardized coefficient	Unstandardized coefficient	SE	Standardized coefficient	Unstandardized coefficient	SE	Standardized coefficient	Unstandardized coefficient	SE
Age	-0.05	-0.45	1.08	0.37**	0.87**	0.26	-0.14	-1.25	1.13
Gender	-0.16	-5.32	3.82	-0.20	-1.72	0.90	-0.12	-3.86	3.85
BMI	0.00	0.01	0.49	0.11	0.12	0.12	-0.02	-0.10	0.48
ADHD subtype	0.15	2.05	1.57	0.06	0.21	0.37	0.14	1.85	1.54
ADHD severity	-0.42***	-0.63***	0.18	-0.14	-0.06	0.04	-0.38**	-0.58**	0.18
MVPA	0.03	0.01	0.05	0.31**	0.03**	0.01	-0.05	-0.02	0.05
Object control							0.24*	0.93*	0.46
R <sup>2</sup>		0.14			0.24			0.18	

Note. \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ . Both standardized and unstandardized regression coefficients are presented. MVPA: moderate-to-vigorous physical activity; SF: social functioning; SCF: school functioning; QOL: quality of life.

TABLE 5: Testing the moderated mediation effect of MVPA on social and school functioning.

(a)				
Predictors	Model 1 (object control)		Model 2 (SF)	
	Unstandardized coefficient	SE	Unstandardized coefficient	SE
Gender	-1.42	0.88	-3.86	5.33
BMI	0.22	0.12	-0.60	0.70
ADHD subtype	0.32	0.36	2.06	2.10
ADHD severity	-0.07	0.04	-0.84**	0.25
MVPA	0.03*	0.01	-0.06	0.07
Age	0.77**	0.25	-1.07	1.60
MVPA×age	0.02**	0.01	0.08	0.05
Object control			1.40*	0.66
Age×object control			0.34	0.44
R <sup>2</sup>	0.31		0.26	

(b)				
Predictors	Model 1 (object control)		Model 2 (SCF)	
	Unstandardized coefficient	SE	Unstandardized coefficient	SE
Gender	-1.42	0.88	4.56	4.04
BMI	0.22	0.12	-0.39	0.54
ADHD subtype	0.32	0.36	0.53	1.61
ADHD severity	-0.07	0.04	-0.41*	0.19
MVPA	0.03*	0.01	-0.01	0.06
Age	0.77**	0.25	-0.02	1.23
MVPA×age	0.02**	0.01	0.01	0.04
Object control			1.08*	0.51
Age×object control			-0.16	0.34
R <sup>2</sup>	0.31		0.15	

Note. \* $p < .05$ ; \*\* $p < .01$ . Unstandardized regression coefficients are presented. MVPA: moderate-to-vigorous physical activity; SF: social functioning; SCF: school functioning.

age. Specifically, the indirect effects of MVPA on social and school functioning were significant for older children with ADHD (social functioning:  $b = 0.05$ ,  $SE = 0.03$ ,  $95\%CI_{boot} = [0.01, 0.11]$ ; school functioning:  $b = 0.03$ ,  $SE = 0.02$ ,  $95\%CI_{boot} = [0.01, 0.07]$ ). However, the indirect effect was not significant for younger children with ADHD (social functioning:  $b = -0.01$ ,  $SE = 0.02$ ,  $95\%CI_{boot} = [-0.05, 0.04]$ ; school functioning:  $b = -0.01$ ,  $SE = 0.02$ ,  $95\%CI_{boot} = [-0.06, 0.03]$ ). Results showed that object control mediated the effect of MVPA on QoL, but a younger age weakened the mediating effect of object control.

#### 4. Discussion

This study is aimed at investigating whether MC mediated the relationship between MVPA and QoL in children with ADHD, and whether age played a moderating role in the direct and indirect relations between MVPA and QoL. The findings partially support the indirect effects of object control skills on the relationship between MVPA and psy-

chological health and overall QoL. Furthermore, age moderated the indirect effects of MVPA on psychological health through object control skills.

Despite that the significant mediating effect of MC was found, the direct association between MVPA and QoL was not found in our study. This was inconsistent with one recent study, demonstrating that a greater frequency of PA contributes to a higher level of QoL in children with ADHD [29]. The possible explanation of this finding may be related to the dose of daily MVPA in children with ADHD. One previous review concluded that increased PA would result in better QoL in children and adolescents [24], but this association was only proved in the TD group. More importantly, they proposed a dose-response relationship between PA and QoL manifesting that an increased PA level by over 2 hours/day could achieve a clinically meaningful change in QoL [24]. In our study, the participants in our study attended averagely 85 minutes of MVPA daily. Although they met the minimum recommended PA guidelines of 60 mins/day, it is still perhaps lacking PA volume that failed to initiate

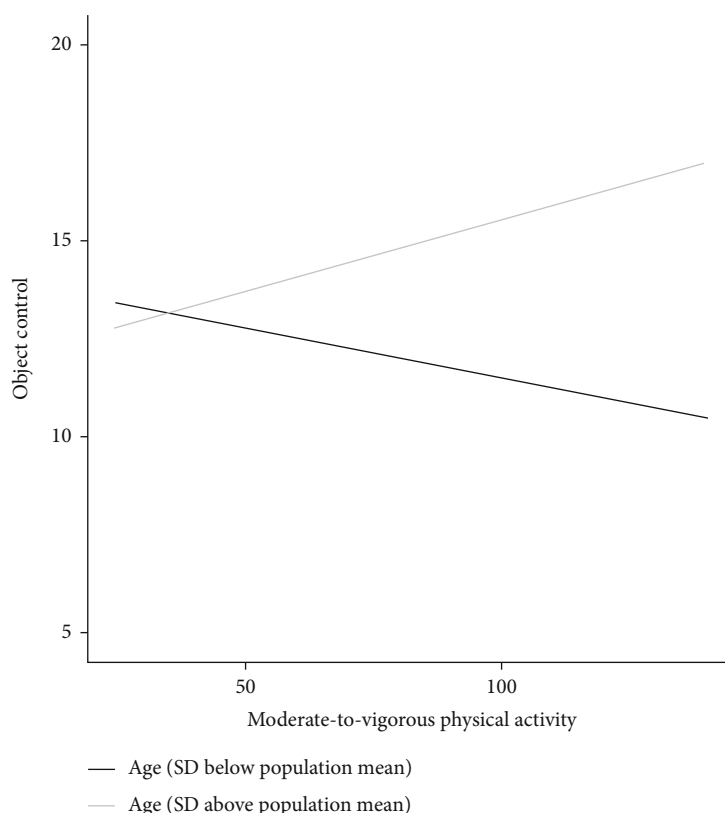


FIGURE 2: Predicted object control against MVPA via the moderation of age.

improvements on QoL, both physically and psychologically. Additionally, although habitual PA per se may be important for various domains of QoL, it may not promote QoL directly. Specific types or quality of activity experiences, rather than overall quantity of PA, may be more related to QoL. Our findings that PA was indirectly associated with QoL via MC may further confirm this speculation. Furthermore, Gallego-Mendez and colleagues' study [20] used child-and-parent reported questionnaire in assessing their PA behaviors, which probably caused measurement bias that could explain the differences from our objective assessments. More studies exploring the relationships between PA and QoL in a larger sample of children with ADHD are needed.

MVPA was found to be positively related to MC, which is consistent with our hypothesis and is supported by previous studies. More physically active children were more likely to master high levels of MC [57]. Unfortunately, children with ADHD are likely to be restricted in participation in various daily activities at school [58], at home [59], and at other community settings [60], which may lead to reduced opportunities for them to acquire motor skills. Although children with ADHD were observed to be clumsy when performing motor skills [10], previous intervention studies indicated that increased levels of PA intervention showed beneficial effects on the development of MC and alleviation of ADHD symptoms in children with ADHD [61]. Our cross-sectional evidence confirmed that enhanced motor skills could be associated with elevated MVPA. Additionally, simply object control skills, rather than locomotion skills,

were positively associated with social and school functioning and general level of QoL. This is aligned with previous findings in children with DCD that ball skills (aiming and catching) were significant related to school aspects of QoL [62]. Object control capacities, which were evaluated through catching and throwing tasks, are more likely to be involved in some specified types of team sports or goal-directed games/activities. In the setting of team sports/games, object control capacity of an individual could be observed from his/her performance in specific motor skills, such as passing, receiving, and shooting in ball games [63]. The proficiency in these motor skills may provide the foundation for peer relationships, as well as physical and psychosocial growth, which may account for the salient role of object control versus locomotion in relation to QoL.

Object control skills significantly mediate the associations between MVPA and psychological functioning (i.e., social and school) and general level of QoL. Previous studies found that exercise interventions with high levels of PA might improve both motor skills and physical health of QoL in children with ADHD [64]. However, the mechanisms underlying the relationships among PA, MC, and QoL remain unclear. Our findings provide preliminary evidence regarding the mechanisms, suggesting that ADHD children who are more physically active may affect their health-related QoL through improved motor proficiency, which interacts to result in positive downstream effects on physical and psychological functioning. Since the cerebellum is responsible for motor control, the abnormalities in the

cerebellum identified in individuals with ADHD may cause delays in motor development [10]. Higher levels of PA boost the activation of the cerebellum, which may explain the exercise-induced MC improvements in children with ADHD. Furthermore, motor performance is linked to the mental representation of activity and other variables such as cognitive functions, social relationships, and physical and psychological health [10]. It is not necessary that children with ADHD could benefit directly from increased MVPA level, unless their MC was adequately improved through activity participation. Kaminsky et al. [65] proposed that health-related physical fitness including MC seems to be more important than PA in relation to health outcomes. Practically, this study informs future challenges to target on MC-oriented PA interventions with the efforts of promoting and maintaining adequate motor skills, instead of simply focusing on PA intensities and frequencies.

Lastly, our findings indicate that age could moderate the relation between MVPA and object control skills as well as indirect path between MVPA and QoL. The relationship between MVPA and MC turns to be stronger in older children in comparison to younger children with ADHD. Plausible explanation could be that as ADHD children getting older, physical activity participation is more facilitative for shaping motor skills. These findings, to some extent, confirm the previous speculations that the relationship between PA and MC evolves as children age [42]. Additionally, the moderating role of age in the indirect path from MVPA to social and school functioning implies that older children tend to benefit from MVPA on their psychological functioning through gaining proficiency in object control capacities. We encourage educators to consider age-appropriate strategies with the incorporation of more ball skills training in children's daily activities as they grow up. In other words, it is never too late for children to become physically active as it benefits them with different mechanisms.

The current study had several strengths (e.g., objectively measuring PA by accelerometer and utilizing TGMD-3 to evaluate MC). However, several limitations should be addressed. First, although it was recommended that the appropriate sample size to test a mediating effect using the bootstrapping method should be at least ranging from 50 to 100 participants [66], the relatively small sample size in our study may result in low statistical power to detect existing associations. Second, the perception of QoL was simply parent-reported. As the previous review found substantial variations in the parent-child agreement in their perception of QoL [20], and children and adolescents with ADHD tend to report their QoL less negatively than their parents [22], this may be a source of bias affecting the results. Future studies should consider exploring both child- and parent-rated QoL. Third, TGMD-3 is appropriate for evaluating children's basic motor skills aged 3-10 years old. This study included a small percentage (5.8%) of participants older than 10 years old, whose performance might reach the ceiling effect of the TGMD-3 scale. Their true level of motor skill might not have been measured accurately, which probably causes bias to the moderating effect of age. Lastly, due to the great unbalance of gender

distribution of ADHD itself, the moderating effect of gender was not explored.

## 5. Conclusion

Although further replication and extensions are necessary, the present study is an important step in unpacking how MVPA relates to various aspects of QoL of children with ADHD. Since MC served as one potential mechanism by which MVPA were correlated to QoL, it remains important to address motor impairment directly or intervene in a manner that promote the impact of MVPA on QoL. Our results may inform future expeditions of how nonpharmacological intervention (e.g., PA intervention) may help to improve MC, and therefore, QoL in children with ADHD. Particularly, age-appropriate strategies with increased MC-oriented intervention could help children with ADHD maximize benefits on health-related outcomes.

## Data Availability

All data generated or analyzed during this study were included in the article.

## Disclosure

The funder had no involvement in the design of the study, analysis, and interpretation of data, decision to publish, or preparation of the manuscript.

## Conflicts of Interest

The authors state that there are no conflicts of interest present.

## Acknowledgments

We thank for all participants and their parents for their great contribution in this study. This work was supported by the Philosophy and Social Science Program of Guangdong Province (Number: GD19YTY02) and Sanming Project of Medicine in Shenzhen "The ADHD research group from Peking University Sixth hospital" (Number: SZSM201612036).

## References

- [1] American Psychiatric Association, *Diagnostic and Statistical Manual of Mental Disorders (DSM-5®)*, American Psychiatric Publishing, Arlington, 2013.
- [2] K. Sayal, V. Prasad, D. Daley, T. Ford, and D. Coghill, "ADHD in children and young people: prevalence, care pathways, and service provision," *The Lancet Psychiatry*, vol. 5, no. 2, pp. 175–186, 2018.
- [3] E. G. Willcutt, "The prevalence of DSM-IV attention-deficit/hyperactivity disorder: a meta-analytic review," *Neurotherapeutics*, vol. 9, no. 3, pp. 490–499, 2012.
- [4] T. S. Nøvik, A. Hervas, S. J. Ralston et al., "Influence of gender on attention-deficit/hyperactivity disorder in Europe-ADORE," *European Child & Adolescent Psychiatry*, vol. 15, no. S1, pp. i15–i24, 2006.

- [5] F. D. Mowlem, M. A. Rosenqvist, J. Martin, P. Lichtenstein, P. Asherson, and H. Larsson, "Sex differences in predicting ADHD clinical diagnosis and pharmacological treatment," *European Child & Adolescent Psychiatry*, vol. 28, no. 4, pp. 481–489, 2019.
- [6] M. L. Wolraich, C. J. Wibbelsman, T. E. Brown et al., "Attention-deficit/hyperactivity disorder among adolescents: a review of the diagnosis, treatment, and clinical implications," *Pediatrics*, vol. 115, no. 6, pp. 1734–1746, 2005.
- [7] C. Gillberg, "The ESSENCE in child psychiatry: early symptomatic syndromes eliciting neurodevelopmental clinical examinations," *Research in Developmental Disabilities*, vol. 31, no. 6, pp. 1543–1551, 2010.
- [8] G. M. De Boo and P. J. M. Prins, "Social incompetence in children with ADHD: possible moderators and mediators in social-skills training," *Clinical Psychology Review*, vol. 27, no. 1, pp. 78–97, 2007.
- [9] V. Sung, H. Hiscock, E. Sciberras, and D. Efron, "Sleep problems in children with attention-deficit/hyperactivity Disorder," *Archives of Pediatrics & Adolescent Medicine*, vol. 162, no. 4, pp. 336–342, 2008.
- [10] J. B. Goulardins, J. C. B. Marques, and J. A. De Oliveira, "Attention deficit hyperactivity disorder and motor Impairment," *Perceptual and Motor Skills*, vol. 124, no. 2, pp. 425–440, 2017.
- [11] T. D. Barry, R. D. Lyman, and L. G. Klinger, "Academic underachievement and attention-deficit/hyperactivity disorder: the negative impact of symptom severity on school performance," *Journal of School Psychology*, vol. 40, no. 3, pp. 259–283, 2002.
- [12] A. Diamond, "Executive functions," *Annual Review of Psychology*, vol. 64, no. 1, pp. 135–168, 2013.
- [13] L. Vaivre-Douret, C. Lalanne, and B. Golse, "Developmental coordination disorder, an umbrella term for motor impairments in children: nature and co-morbid disorders," *Frontiers in Psychology*, vol. 7, p. 502, 2016.
- [14] J. G. Zwicker, C. Missiuna, and L. A. Boyd, "Neural correlates of developmental coordination disorder: a review of hypotheses," *Journal of Child Neurology*, vol. 24, no. 10, pp. 1273–1281, 2009.
- [15] P. Çaçola and M. Killian, "Health-related quality of life in children with developmental coordination disorder: association between the PedsQL and KIDSCREEN instruments and comparison with their normative samples," *Research in Developmental Disabilities*, vol. 75, pp. 32–39, 2018.
- [16] H. C. Karras, D. N. Morin, K. Gill, S. Izadi-Najafabadi, and J. G. Zwicker, "Health-related quality of life of children with developmental coordination disorder," *Research in Developmental Disabilities*, vol. 84, pp. 85–95, 2019.
- [17] D. Dewey and A. Volkovinskaia, "Health-related quality of life and peer relationships in adolescents with developmental coordination disorder and attention-deficit-hyperactivity disorder," *Developmental Medicine and Child Neurology*, vol. 60, no. 7, pp. 711–717, 2018.
- [18] T. W. Group, "The World Health Organization quality of life assessment (WHOQOL): position paper from the World Health Organization," *Social Science & Medicine*, vol. 41, no. 10, pp. 1403–1409, 1995.
- [19] P. M. Wehmeier, A. Schacht, and R. A. Barkley, "Social and emotional impairment in children and adolescents with ADHD and the impact on quality of life," *Journal of Adolescent Health*, vol. 46, no. 3, pp. 209–217, 2010.
- [20] Y. C. Lee, H. J. Yang, V. C. H. Chen et al., "Meta-analysis of quality of life in children and adolescents with ADHD: by both parent proxy-report and child self-report using PedsQL™," *Research in Developmental Disabilities*, vol. 51–52, no. 110, pp. 160–172, 2016.
- [21] J. C. B. Marques, J. A. Oliveira, J. B. Goulardins, R. O. Nascimento, A. M. V. Lima, and E. B. Casella, "Comparison of child self-reports and parent proxy-reports on quality of life of children with attention deficit hyperactivity disorder," *Health and Quality of Life Outcomes*, vol. 11, no. 1, pp. 1–7, 2013.
- [22] M. Danckaerts, E. J. S. Sonuga-Barke, T. Banaschewski et al., "The quality of life of children with attention deficit/hyperactivity disorder: a systematic review," *European Child & Adolescent Psychiatry*, vol. 19, no. 2, pp. 83–105, 2010.
- [23] D. Lubans, J. Richards, C. Hillman et al., "Physical activity for cognitive and mental health in youth: A systematic review of mechanisms," *Pediatrics*, vol. 138, no. 3, 2016.
- [24] A. M. Marker, R. G. Steele, and A. E. Noser, "Physical activity and health-related quality of life in children and adolescents: a systematic review and meta-analysis," *Health Psychology*, vol. 37, no. 10, pp. 893–903, 2018.
- [25] S. W. W. b. S. S. Wafa, M. R. b. Shahril, A. b. Ahmad et al., "Association between physical activity and health-related quality of life in children: a cross-sectional study," *Health and Quality of Life Outcomes*, vol. 14, no. 1, pp. 1–6, 2016.
- [26] World Health Organization, *WHO Guidelines on Physical Activity and Sedentary Behaviour*, World Health Organization, Geneva, Switzerland, 2020.
- [27] C. Y. Lin, A. L. Yang, and C. T. Su, "Objective measurement of weekly physical activity and sensory modulation problems in children with attention deficit hyperactivity disorder," *Research in Developmental Disabilities*, vol. 34, no. 10, pp. 3477–3486, 2013.
- [28] C.-L. Yu, T.-Y. Chueh, S.-S. Hsieh et al., "Motor competence moderates relationship between moderate to vigorous physical activity and resting EEG in children with ADHD," *Mental Health and Physical Activity*, vol. 17, article 100302, 2019.
- [29] J. Gallego-Méndez, J. Perez-Gomez, J. I. Calzada-Rodríguez et al., "Relationship between health-related quality of life and physical activity in children with hyperactivity," *International Journal of Environmental Research and Public Health*, vol. 17, no. 8, 2020.
- [30] M. Haga, "The relationship between physical fitness and motor competence in children," *Child: Care, Health and Development*, vol. 34, no. 3, pp. 329–334, 2008.
- [31] D. R. Lubans, P. J. Morgan, D. P. Cliff, L. M. Barnett, and A. D. Okely, "Fundamental movement skills in children and adolescents," *Sports Medicine*, vol. 40, no. 12, pp. 1019–1035, 2010.
- [32] T. M. Pitcher, J. P. Piek, and D. A. Hay, "Fine and gross motor ability in males with ADHD," *Developmental Medicine and Child Neurology*, vol. 45, no. 8, pp. 525–535, 2003.
- [33] B. H. Wrotniak, L. H. Epstein, J. M. Dorn, K. E. Jones, and V. A. Kondilis, "The relationship between motor proficiency and physical activity in children," *Pediatrics*, vol. 118, no. 6, pp. e1758–e1765, 2006.
- [34] L. M. Barnett, P. J. Morgan, E. Van Beurden, K. Ball, and D. R. Lubans, "A reverse pathway? Actual and perceived skill proficiency and physical activity," *Medicine & Science in Sports & Exercise*, vol. 43, no. 5, pp. 898–904, 2011.



- [35] C. Y. Pan, Y. K. Chang, C. L. Tsai, C. H. Chu, Y. W. Cheng, and M. C. Sung, "Effects of physical activity intervention on motor proficiency and physical fitness in children with ADHD: an exploratory study," *Journal of Attention Disorders*, vol. 21, no. 9, pp. 783–795, 2017.
- [36] S. Ziereis and P. Jansen, "Effects of physical activity on executive function and motor performance in children with ADHD," *Research in Developmental Disabilities*, vol. 38, pp. 181–191, 2015.
- [37] E. Bremer and J. Cairney, "Fundamental movement skills and health-related outcomes: a narrative review of longitudinal and intervention studies targeting typically developing children," *American Journal of Lifestyle Medicine*, vol. 12, no. 2, pp. 148–159, 2018.
- [38] A. Redondo-Tebar, I. G. Fatouros, V. Martinez-Vizcaino, A. Ruiz-Hermosa, B. Notario-Pacheco, and M. Sanchez-Lopez, "Association between gross motor competence and health-related quality of life in (pre)schoolchildren: the mediating role of cardiorespiratory fitness," *Physical Education and Sport Pedagogy*, vol. 26, no. 1, pp. 51–64, 2021.
- [39] S. N. Blair, Y. Cheng, and J. Scott Holder, "Is physical activity or physical fitness more important in defining health benefits?," *Medicine and Science in Sports and Exercise*, vol. 33, Supplement, pp. S379–S399, 2001.
- [40] D. F. Stodden, Z. Gao, J. D. Goodway, and S. J. Langendorfer, "Dynamic relationships between motor skill competence and health-related fitness in youth," *Pediatric Exercise Science*, vol. 26, no. 3, pp. 231–241, 2014.
- [41] R. A. Lima, K. Pfeiffer, L. R. Larsen et al., "Physical activity and motor competence present a positive reciprocal longitudinal relationship across childhood and early adolescence," *Journal of Physical Activity and Health*, vol. 14, no. 6, pp. 440–447, 2017.
- [42] E. A. Schmutz, C. S. Leeger-Aschmann, T. H. Kakebeeke et al., "Motor competence and physical activity in early childhood: stability and relationship," *Frontiers in Public Health*, vol. 8, p. 39, 2020.
- [43] H. Zhang, "The revision of WISC-IV Chinese version," *Psychological Science*, vol. 5, pp. 1177–1179, 2009.
- [44] J. Kaufman, B. Birmaher, D. Brent et al., "Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version (K-SADS-PL): Initial Reliability and Validity Data," *Journal of the American Academy of Child and Adolescent Psychiatry*, vol. 36, no. 7, pp. 980–988, 1997.
- [45] Y. Liu, J. Liu, and Y. Wang, "Reliability and validity of Chinese version of the mini international neuropsychiatric interview for children and adolescents (parent version)," *Chinese Mental Health Journal*, vol. 24, no. 12, pp. 921–925, 2010.
- [46] J. H. Migueles, A. V. Rowlands, F. Huber, S. Sabia, and V. T. van Hees, "GGIR: a research community-driven open source R package for generating physical activity and sleep outcomes from multi-day raw accelerometer data," *Journal for the Measurement of Physical Behaviour*, vol. 2, no. 3, pp. 188–196, 2019.
- [47] M. Hildebrand, V. T. van Hees, B. H. Hansen, and U. Ekelund, "Age group comparability of raw accelerometer output from Wrist- and hip-worn monitors," *Medicine and Science in Sports and Exercise*, vol. 46, no. 9, pp. 1816–1824, 2014.
- [48] D. A. Ulrich, "The test of gross motor development-3 (TGMD-3): administration, scoring, and international norms," *Spor Bilimleri Dergisi*, vol. 24, no. 2, pp. 27–33, 2013.
- [49] Y. Diao, C. Dong, and J. Li, "The establishment of norm of gross motor development test in Shanghai," *China Sport Science and Technology*, vol. 54, no. 2, pp. 98–104, 2018.
- [50] C. M. Capio, C. H. P. Sit, and B. Abernethy, "Fundamental movement skills testing in children with cerebral palsy," *Disability and Rehabilitation*, vol. 33, no. 25–26, pp. 2519–2528, 2011.
- [51] J. W. Varni, M. Seid, and P. S. Kurtin, "PedsQL™ 4.0: reliability and validity of the pediatric quality of life inventory™ version 4.0 generic Core scales in healthy and patient populations," *Medical Care*, vol. 39, no. 8, pp. 800–812, 2001.
- [52] Y. Hao, Q. Tian, Y. Lu, Y. Chai, and S. Rao, "Psychometric properties of the Chinese version of the Pediatric Quality of Life Inventory™ 4.0 generic core scales," *Quality of Life Research*, vol. 19, no. 8, pp. 1229–1233, 2010.
- [53] S. S. Gau, C. Shang, S. Liu et al., "Psychometric properties of the Chinese version of the Swanson, Nolan, and Pelham, version IV scale-parent form," *International Journal of Methods in Psychiatric Research*, vol. 17, no. 1, pp. 35–44, 2008.
- [54] H. W. S. Bao, "Bruce R: Broadly useful convenient and efficient R functions," <https://CRAN.R-project.org/package=bruceR>.
- [55] A. F. Hayes, *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*, Guilford Press, New York, 2017.
- [56] R. B. Kline, *Principles and Practice of Structural Equation Modeling*, Guilford press, New York, 2015.
- [57] A. Kambas, M. Michalopoulou, I. G. Fatouros et al., "The relationship between motor proficiency and pedometer-determined physical activity in young children," *Pediatric Exercise Science*, vol. 24, no. 1, pp. 34–44, 2012.
- [58] B. Hoza, "Peer functioning in children with ADHD," *Journal of Pediatric Psychology*, vol. 32, no. 6, pp. 655–663, 2007.
- [59] S. Thomas, E. Sciberras, K. Lycett, N. Papadopoulos, and N. Rinehart, "Physical functioning, emotional, and behavioral problems in children with ADHD and comorbid ASD: a cross-sectional study," *Journal of Attention Disorders*, vol. 22, no. 10, pp. 1002–1007, 2018.
- [60] V. A. Harpin, "The effect of ADHD on the life of an individual, their family, and community from preschool to adult life," *Archives of Disease in Childhood*, vol. 90, suppl\_1, pp. i2–i7, 2005.
- [61] C. Verret, M. C. Guay, C. Berthiaume, P. Gardiner, and L. Béliveau, "A physical activity program improves behavior and cognitive functions in children with ADHD: an exploratory study," *Journal of Attention Disorders*, vol. 16, no. 1, pp. 71–80, 2012.
- [62] S. Raz-Silbiger, N. Lifshitz, N. Katz, S. Steinhart, S. A. Cermak, and N. Weintraub, "Relationship between motor skills, participation in leisure activities and quality of life of children with developmental coordination disorder: temporal aspects," *Research in Developmental Disabilities*, vol. 38, pp. 171–180, 2015.
- [63] X. Gu, K. T. Thomas, and Y.-L. Chen, "The role of perceived and actual motor competency on children's physical activity and cardiorespiratory fitness during middle childhood," *Journal of Teaching in Physical Education*, vol. 36, no. 4, pp. 388–397, 2017.
- [64] C. F. Meßler, H.-C. Holmberg, and B. Sperlich, "Multimodal therapy involving high-intensity interval training improves the physical fitness, motor skills, social behavior, and quality of life of boys with ADHD: a randomized controlled study,"

*Journal of Attention Disorders*, vol. 22, no. 8, pp. 806–812, 2018.

- [65] L. A. Kaminsky, R. Arena, T. M. Beckie et al., “The importance of cardiorespiratory fitness in the United States: the need for a national registry: a policy statement from the American Heart Association,” *Circulation*, vol. 127, no. 5, pp. 652–662, 2013.
- [66] E. Cerin, L. M. Taylor, E. Leslie, and N. Owen, “Small-scale randomized controlled trials need more powerful methods of mediational analysis than the Baron–Kenny method,” *Journal of Clinical Epidemiology*, vol. 59, no. 5, pp. 457–464, 2006.



## Research Article

# Feasibility and Effectiveness of the Web-Based WeActive and WeMindful Interventions on Physical Activity and Psychological Well-Being

Michele W. Marenus<sup>1</sup> ,<sup>1</sup> Andy Murray<sup>1</sup> ,<sup>1</sup> Kathryn Friedman,<sup>1</sup> Julia Sanowski,<sup>1</sup> Haley Ottensoser,<sup>1</sup> Ana Cahuas,<sup>2</sup> Varun Kumaravel,<sup>1</sup> and Weiyun Chen<sup>1</sup> 

<sup>1</sup>School of Kinesiology, University of Michigan, Ann Arbor, MI 48109, USA

<sup>2</sup>Department of Psychology, University of Michigan, Ann Arbor, MI 48109, USA

Correspondence should be addressed to Weiyun Chen; [chenwy@umich.edu](mailto:chenwy@umich.edu)

Received 29 June 2021; Revised 14 September 2021; Accepted 22 September 2021; Published 4 October 2021

Academic Editor: Zan Gao

Copyright © 2021 Michele W. Marenus et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

This study is aimed at examining the feasibility and effectiveness of aerobic and resistance training (WeActive) and mindful exercise (WeMindful) interventions in improving physical activity (PA), psychological well-being (PWB), and subjective vitality among college students. Participants in this study were 77 college students who were randomly assigned to either the WeActive group ( $n = 43$ ) or the WeMindful group ( $n = 28$ ). The WeActive group attended two 30-minute aerobic and resistance training sessions per week, and the WeMindful group attended two 30-minute yoga and mindful exercise sessions per week for eight weeks. All participants completed the *International Physical Activity Questionnaire*, the *World Health Organization-Five Well-Being Index*, and the *Subjective Vitality Scale* before and after the intervention, as well as the *Assessing Feasibility and Acceptability Questionnaire* at the end of the intervention. The primary study outcome measures were PA, PWB, and subjective vitality. A repeated-measures ANCOVA indicated a significant main effect of time for total PA ( $F = 7.89, p = 0.006, \eta^2 = 0.049$ ), vigorous PA ( $F = 5.36, p = 0.024, \eta^2 = 0.022$ ), and walking ( $F = 7.34, p = 0.009, \eta^2 = 0.042$ ) in both intervention groups. There was a significant interaction effect of time and group for PWB ( $F = 11.26, p = 0.001, \eta^2 = 0.022$ ), where the WeActive group experienced a decrease in PWB scores while participants in the WeMindful group experienced an increase in PWB scores over time. There was a main effect of group for subjective vitality ( $F = 8.91, p = 0.007, \eta^2 = 0.088$ ), indicating that the WeMindful group experienced a greater increase in subjective vitality than the WeActive group. Further, the participants in both groups indicated that the synchronized and asynchronized Zoom-based WeActive and WeMindful interventions were acceptable, appropriate, and feasible for participants. This study demonstrated that mindful exercise is effective in increasing PA, PWB, and subjective vitality while aerobic and resistance training may only be effective in increasing PA.

## 1. Introduction

Psychological health treatment and prevention have been the forefront of research and university administrations' focus due to the growing rates of mental illness observed in college students [1–3]. College students face unique stressors during this transitory period and often set habits that last beyond their college years [4, 5]. Most research on psychological health has focused on the presence and treatment of mental illness and has framed well-being as simply the absence of

negative functioning [6]. Many researchers argue that psychological health should not just be limited to the lack of dysfunction—it should also focus on the positive aspects of mental health such as psychological well-being (PWB) [7–9]. PWB can be broadly defined as the “optimal psychological functioning and experience” (p. 142), which includes dimensions such as life satisfaction and personal growth [9, 10]. PWB is characterized by two distinct theoretical perspectives: the eudaimonic approach and the hedonic approach [9]. The eudaimonic approach defines well-being according

to the ability of one to identify the life pursuits that are meaningful to them and strive to achieve their best. Vitality, the state of feeling alive and alert, is highly related to eudaimonic well-being [11]. The hedonic approach defines well-being according to pleasure and happiness being pursued and attained. Factors that contribute to one's PWB will differ throughout different ages and different circumstances, making approaches to improving PWB unique to each population [12].

Physical activity (PA) has shown to be an effective way to improve PWB as PA can improve mental health issues such as anxiety and depression and increases well-being [12, 13]. A study on 925 college students in China found that participants' hope, gratitude, life satisfaction, and happiness were significantly related to healthy body weight [14]. An additional study on college students demonstrated that PA was positively associated with higher levels of life satisfaction and happiness. Physical health—which can be maintained through PA—was found to be a positive predictor of PWB in college students [15]. Further, studies have shown that moderate to vigorous PA provides the greatest physical and mental health benefits [16–18]. During the transition to adulthood, research has shown a substantial decrease in PA for young adults [19]. This behavioral change is of particular importance because PA is a modifiable risk factor for poor PWB [20]. Throughout the recent decades, there has been a worldwide increase in obesity, a warning signal of blood pressure diseases, arthritis, cancer, type II diabetes, and CVDs [21], and recent studies have warned about the reduction of physical activities among college students [22]. Therefore, helping university students maintain higher PA from adolescence into adulthood is a major public health challenge.

The spread of the COVID-19 pandemic caused an unprecedented impact on daily life, presenting significant challenges to the development and maintenance of healthy behaviors, especially in college students [23]. COVID-19 has uniquely impacted college students due to insecurity and uncertainty around housing, academics, and future career options [23, 24]. Higher rates of mental illness and distress are typically observed in college students even prior to COVID-19, making them a vulnerable population to the detrimental effects of the pandemic [24, 25]. A systematic review reported that five studies showed a reduction of between 32% and 365.5% in light/moderate walking PA and seven studies showed a reduction between 2.9% and 52.8% reduction in high/vigorous PA, when compared to the prelockdown levels in university students [26]. Due to the COVID-19 pandemic confinements for university students, walking and moderate, vigorous, and total PA levels have been reduced [26]. One study found that individuals who reported over 30 minutes per day of moderate to vigorous PA were less likely to have symptoms of anxiety or depression [27]. Further, there was an observed decrease in PA in Italy, resulting in a negative effect on the well-being of the population [28]. Studies assessing the effects of the pandemic on college students are calling for the development of interventions and preventative measures to address physical and mental health concerns [29].

Different types of exercise have been found to be beneficial for mental and physical health. Due to the stigma associated with a diagnosis of a mental illness, many students may avoid obtaining help for their poor PWB, anxiety, and depression [30]. Mind-body practices, such as yoga, have been shown to help college students cope with stress, anxiety, and depression, which are all related to PWB [31]. Mindful exercises often incorporate mindfulness. Mindfulness is defined as “the awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment by moment” [32] (p. 145). Mindfulness practices have been shown to increase mindful awareness, reduce psychological distress, and improve PWB and subjective vitality in college students [33]. Mindful exercises have been recommended as a nonpharmaceutical practice that can support student well-being [34]. Research examining the relationships between yoga practice and well-being found that there was a correlation between the number of years practicing yoga and gratitude and meaning in life [35]. Further, an intervention conducted with 20 healthy college students found that participants who attended a 90-minute yoga class twice per week for eight weeks experienced significant improvements in their positive and negative effects [36]. Another study on college students in India found that participants saw significant improvement in PWB after completion of six 45-minute yoga sessions each week for three months, compared to a control group [37]. This research shows the overall positive impact of mind-body exercises.

Studies have also shown that aerobic and resistance training exercises have positive effects on the mental health and well-being of college students [38–40]. In a randomized control trial study of effects of a six-week aerobic exercise program in 30 female college students, the experimental group ( $n = 15$ ) had greater improvement in mental health indices such as social function, anxiety, and depression compared to the control group ( $n = 15$ ) [22]. A study on 44 women, who were assigned to either aerobic dance exercise class three times per week for eight weeks or a control group, found that the participants in the experimental group showed significant improvements in their eudaimonic well-being, compared to the control counterparts [41]. Similarly, other studies have observed psychological benefits after participating in resistance training in adults [42]. One intervention study that assessed the impact of 12-week resistance training sessions found that participants who attended at least twice per week saw slight improvements in mental health, compared to the control group [43]. In short, studies have indicated that both aerobic exercise and resistance training may enhance overall well-being. Given the limited number of intervention studies that examine the effects of aerobic and resistance training on PWB in college students, there is a need to further research in this area.

Web-based physical activity interventions may be particularly effective in promoting health behaviors in college students [39, 44]. A systematic review found that providing virtual PA programs improves limitations that are traditionally experienced during in-person or print-based interventions while maintaining similar effectiveness outcomes. Some of these improvements include increased flexibility and the

ability to access more people at a low cost [45]. A study on college students in Hong Kong supported the feasibility of internet-based interventions in promoting mental health [46]. They found that an 8-week 30-to-45-minute internet-based mindfulness training significantly enhanced mental well-being at posttest and 3-month follow-up when compared with the waitlist control [46]. Additionally, reminder emails have been found to enhance the effectiveness of the intervention if they are proactively sent to participants during the duration of the web-based intervention [47]. A meta-analysis of e-health interventions found that internet-based PA interventions are effective in increasing PA participation in young people [48]. Of the 10 studies included in the meta-analysis, six studies were randomized control trials, three were quasiexperimental, and one was a cluster randomized control. Eight of the 10 studies reported increases in PA and showed sustainment up to eight months postintervention [48]. Further, studies that had a theoretical framework for the intervention were found to be the most successful.

Web-based exercise programming is an emerging intervention approach to help meet the needs of college students during the COVID-19 pandemic. Aerobic and resistance training and mindful exercises have both shown promise in improving psychological health. Providing two popular forms of PA for college students may be beneficial for participation and engagement. However, studies examining the effectiveness and feasibility of these programs are scarce. To the best of our knowledge, few studies have compared the effects of PA (specifically aerobic exercise and resistance training) with mindful exercise on increasing PA and improving well-being concurrently in college students. Thus, the purpose of this study was to examine the feasibility and effectiveness of the Zoom-based aerobic and resistance exercise intervention (WeActive) and the Zoom-based mindful exercise intervention (WeMindful) in improving PWB, subjective vitality, and PA among college students over the course of eight weeks during an academic semester. We hypothesized that both groups would show an increase in PWB, and subjective vitality, and PA based on previous studies demonstrating that PA and yoga interventions are effective in increasing these outcomes. Further, we believed that the aerobic and resistance exercise group would experience a greater increase in moderate to vigorous PA compared to the mindful exercise group due to the participation in intervention activities which include moderate to vigorous exercise as part of the WeActive group lessons. This study will help researchers and interventionists further understand the benefits of different modes of exercise on improving PA and PWB through a web-based platform. This study uniquely contributes to the literature by comparing two popular forms of exercise and examining the effects on PA participation and PWB.

## 2. Methods

**2.1. Participants and Study Design.** In this study, participants were 77 college students enrolled in a large midwestern research university. There were 61 cisgender females, 6 cisgender males, and 5 transgender and gender nonconforming (TGNC) people. The average age was 23.43 (SD = 6), and

approximately 65% of participants were white (see the full demographic breakdown in Table 1). Students were recruited via the University of Michigan's targeted email request system, the learning management system used by the university named Canvas, social media, and the undergraduate and graduate bulletins of the School of Kinesiology. Inclusion criteria for this study were (1) the ability to participate in intervention activities, (2) the ability to participate in all assessments, (3) completion of the consent form, and (4) enrollment as a student at the University of Michigan. Exclusion criteria were limited to the lack of ability to exercise regularly due to injury or illness. The study was approved by the University Institutional Review Board (IRB#HUM00189120/Ame00107415) of Health and Behavioral Sciences. Participants provided written consent prior to participation.

This study used a two-arm quasiexperimental design. All participants completed a baseline online Qualtrics survey within a week prior to random assignment into either WeActive or WeMindful intervention. Both interventions lasted 8 weeks during a winter/spring semester of 2021, and each participant completed a posttest online Qualtrics survey one week after the completion of the intervention. Both pre- and posttest Qualtrics surveys included measures on physical activity, psychological well-being, and subjective vitality. In addition, the baseline survey asked participants to report if they had regularly engaged in the following activities regularly over the last three months: (1) aerobic and strength exercises, (2) mindful exercises such as yoga, and (3) psychological and cognitive services. Participants were also asked to self-rate their overall health, on a five-point scale.

**2.1.1. Intervention Conditions and Components.** *WeActive intervention group.* Participants attended two 30-minute Zoom-based exercise lessons per week for 8 weeks. Participants had the option to attend a live Zoom class or watch the recording of the session. The WeActive exercise lessons were taught by a student instructor who is a Certified Strength and Conditioning Specialist (CSCS) through the National Strength and Conditioning Association (NSCA) and had 5 years of experience teaching fitness classes and training. Each lesson consisted of a 5-minute warm-up with low-impact walking steps with dynamic stretching exercises, 20-minute aerobic and strength exercises, and a 5-minute cool-down with static stretching exercises. The strength training exercises typically included lower-body, upper-body, and core areas using circuit-training methods. The first four weeks focused mostly on strength, and the second four weeks involved more high-impact aerobic and strength training based on feedback from participants. When teaching each lesson, the instructor started with demonstrating each exercise and explained any modifications, then led the participants to perform the exercise with modification. The instructor provided learning cues and motivational cues throughout performing the exercises. At the end of each lesson, there was a quick review of the key points of the lesson. Each lesson video and the written lesson plan were posted on the Canvas study site to help participants repeat the lessons on their own time. Every week, we also sent an email notification to remind participants of their goals for the week and to provide positive reinforcement.

TABLE 1: Demographic data of total participant group.

Variables	n	%
Gender		
Cisgender female	60	65%
Cisgender male	6	31%
Transgender & gender nonconforming (TNGC)	5	4%
Race		
Asian	14	20%
Black or African American	4	6%
White	45	63%
Multiracial	8	11%
Ethnicity		
Hispanic	6	8%
Non-Hispanic	65	90%
Education status		
1 <sup>st</sup> year	7	10%
2 <sup>nd</sup> year	9	13%
3 <sup>rd</sup> year	15	21%
4 <sup>th</sup> year+	14	19%
Master's	12	17%
Professional	2	3%
Doctoral	12	17%

The objective of the WeActive interventions was to help students engage in 150 minutes or more of moderate to vigorous PA per week and maintain the recommended amount of weekly PA throughout the course of eight weeks. We posted a variety of exercise videos to our study website, and we encouraged the participants to use the lessons multiple times over the week at their discretion and to participate with peers.

*WeMindful intervention group.* Participants attended two 30-minute Zoom-based mindful exercise lessons per week for 8 weeks. Participants had the option to attend a live Zoom class or watch the recording of the session. The WeMindful exercise lessons were taught by a senior student majoring in movement science. The student-instructor has had prior experience with group yoga for two years and has three years of experience teaching group exercise classes. Each lesson consisted of a 5-minute mindful warm-up focusing on mindful breathing, a 20-minute yoga practice, and a 5-minute mindfulness practice to close. The yoga practice typically included a flow of a variety of poses that increased with difficulty towards the latter weeks of the intervention. When teaching each lesson, the instructor demonstrated the yoga movement while providing learning cues, then led the participants in practicing the yoga pose and movement. The instructor used the tell-show-do methods to teach each of 4-6 yoga poses and transition movements. The instructor used similar teaching methods to engage the participants in performing all the poses and transition moves in a sequence. Throughout the process of leading the practices, the instructor provided learning cues and motivational cues to engage the participants in performing each yoga and transition move correctly. At the

end of each lesson, the instructor guided the participants in a mindfulness practice by providing verbal cues. Each lesson video and the written lesson plan were posted on our study website to help participants repeat the lessons on their own time. Every week, we sent an email notification to remind participants of their goals for the week and to provide positive reinforcement.

*2.2. Peer Coaching Component.* In addition to the exercise conditions, we offered one 30-minute zoom-based peer coaching session per two weeks to help participants set goals, reflect on their strengths and priorities, self-monitor their progression towards their goals, and leverage their social support. These sessions were offered to all study participants. Participants were given journal prompts every two weeks to encourage self-awareness in relation to the topics listed above. Journal prompts were posted on the study website for participants to use. Additionally, we asked participants to share their exercise experiences, their thoughts and feelings about the exercise lessons, barriers or challenges they have faced, and any suggestions for the following weeks of the intervention. The strategies that were used in each session were grounded on the evidence-based behavior change techniques that have been effective in increase PA [49]. Each peer coaching session was also posted on the study website. The peer coaching sessions were run by a doctoral student who has been trained in motivational interviewing and an undergraduate student who majored in psychology.

*2.3. Data Collection and Outcome Measures.* The online questionnaire was distributed via Qualtrics one week prior to the start of the intervention and one week after the completion of the intervention. The questionnaire assessed PA, PWB, and subjective vitality. In addition, the baseline survey asked participants to report if they had regularly engaged in the following activities over the last three months: (1) aerobic and strength exercises, (2) mindful exercises such as yoga, and (3) psychological and cognitive services. Participants were also asked to self-rate their overall health, on a five-point scale. Further, intervention outcomes were also assessed during the posttest.

*Physical activity.* The International Physical Activity Questionnaire- (IPAQ-) Short Form is a 7-item measure to assess levels of PA intensity [50]. Participants were asked to recall the days, hours, and minutes spent on vigorous physical activity (VPA), moderate physical activity (MPA), and walking in the last week. PA scores were indicated by the metabolic equivalent (MET) minutes per week. VPA MET-minutes/week was calculated by multiplying the total minutes per week in VPA by 8.8. MPA MET-minutes/week was calculated by multiplying the number of minutes per week in MPA by 4.0. Walking MET-minutes/week was calculated by multiplying the number of minutes per week walking by 3.3. The total PA (TPA) MET-minutes/week was calculated by adding VPA MET-minutes/week, MPA MET-minutes/week, and walking MET-minutes/week. Examples of questions are “during the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or double tennis?” and “how much time did you usually spend



doing moderate physical activities on one of those days?" This questionnaire has demonstrated internal reliability in both the baseline (Cronbach  $\alpha = 0.72$ ) and posttest (Cronbach  $\alpha = 0.73$ ) and is valid for use with young adults.

**Psychological well-being (PWB).** The World Health Organization-Five Well-Being Index (WHO-5) is a short self-report assessment of current mental well-being [51]. The WHO-5 is comprised of the following five statements: (1) "I have felt cheerful and in good spirits," (2) "I have felt calm and relaxed," (3) "I have felt active and vigorous," (4) "I woke up feeling fresh and rested," and (5) "My daily life has been filled with things that interest me." Participants were asked to indicate which response that felt closest to how they have felt over the last two weeks on a 6-point rating scale, ranging from 5 = all the time to 0 = at no time. Total scores are calculated by adding the five items. The WHO-5 had high internal reliability in this study at both baseline (Cronbach  $\alpha = 0.85$ ) and posttest (Cronbach  $\alpha = 0.89$ ).

**Vitality.** The Subjective Vitality Scale (SVS) was designed to assess individuals' feelings of vitality using 7 items on a 7-point rating scale [11]. Vitality is highly related to eudemonic well-being. The participants were asked to indicate the degree to which the statements are true for their lives. Responses range from 1 = not true at all to 7 = very true. Sample items include "I feel alive and vital," "I look forward to each new day," and "I feel energized." The total score was calculated by averaging the scores of the individual items. The SVS had high internal reliability in this study in both the baseline (Cronbach  $\alpha = 0.9$ ) and posttest (Cronbach  $\alpha = 0.89$ ) scores.

**Intervention feasibility and acceptability.** The Assessing Intervention Feasibility and Acceptability (AIFA) questionnaire was designed to measure intervention implementation outcomes [52]. Participants completed the 12-item AIFA on a 5-point rating scale at the conclusion of the intervention. The AIFA consisted of three subscales: acceptability, appropriateness, and feasibility. Each subscale had 4 items. Sample items include the following: "The intervention strategies are appealing to me" (acceptability), "The intervention components seem applicable" (appropriateness), and "The intervention components seem doable" (feasibility).

Participants were asked to rate their agreement with each statement on a 5-point rating scale, ranging from 5 = strongly agree to 1 = strongly disagree. Scores for each subscale were calculated by adding up the items that correspond to the subscale. Total scores were calculated by adding all the items on the survey. This questionnaire demonstrated internal reliability (Cronbach  $\alpha = 0.94$ ) in this study.

**2.4. Data Analysis.** Among 77 participating students, three were excluded due to lack of participation and five were excluded from the final data analysis due to missing data in the outcome measures. The missing data were screened by using listwise deletion. The final data set included 71 participants, 43 in the WeActive intervention group and 28 in the WeMindful intervention group.

An independent sample *t*-test was performed on the baseline data to determine if there were significant differences in the outcome variables and the demographic variables between

the two groups in order to determine which type of analysis was needed to examine the data. The results showed an overall significant difference in mean scores of the baseline PWB scores between the two groups,  $t(66.59) = -1.96, p = 0.054$ . Additionally, there was a significant difference in participants' reports of attending psychological or cognitive services in the last three months by group,  $t(49.15) = 2.53, p = 0.015$ . Since significant differences were observed at baseline, a repeated-measures analysis of covariance (ANCOVA) was used to examine the effects of the intervention on posttest PA variables, PWB, and vitality by group while statistically controlling for covariates (pretest PWB scores and psychological service attendance). The between-factor was the intervention group (WeActive vs. WeMindful), and the within-subjects factor was time (baseline vs. posttest).

### 3. Results

Table 2 present the baseline and posttest scores by group. Skewness and kurtosis were checked for normality, and logistic transformations were performed on PA data due to violations of normality. Regarding the PA outcome variables, the IPAQ scoring guidelines indicate that individuals who engage in at least 1500 MET-minutes/week of VPA or at least 3000 MET-minutes of TPA are considered "high" active. Individuals who engaged in less than 3000 MET-minutes/week of TPA but greater than 600 MET-minutes/week of TPA were considered "moderate" active [53]. Individuals who engaged in below 600 MET-minutes/week of TPA were considered "low" active. Table 3 displays the percentage by group of participants who are considered "high," "moderate," and "low" active both by baseline and posttest. Both groups observed an increase in the number of participants who were considered "high" and "moderate" active.

Regarding PWB well-being scores, scores below 13 indicate poor well-being. Both groups in this study were below 13 for both the pretest and posttest [54]. However, the WeActive group saw a decrease in PWB scores from baseline to posttest while WeMindful saw an increase in PWB scores from baseline to posttest. Regarding subjective vitality, both groups saw an increase in vitality scores from baseline to posttest.

**3.1. Intervention Effects on Physical Activity.** Table 4 shows the results of a repeated-measures ANCOVA for all PA variables. While controlling for pretest PWB and psychological services attended, repeated-measures ANCOVA showed that there was no significant main effect of group and no significant interaction of time with group for weekly walking, VPA, MPA, and TPA MET-minutes. However, there was a significant main effect of time for TPA ( $F = 7.89, p = 0.006, \eta^2 = 0.049$ ), VPA ( $F = 5.36, p = 0.024, \eta^2 = 0.022$ ), and walking ( $F = 7.34, p = 0.009, \eta^2 = 0.042$ ). There was no main effect of time for MPA. The results indicate that both groups experienced an increase in TPA, VPA, and walking after the 8-week interventions.

**3.2. Intervention Effects on Psychological Well-Being and Subjective Vitality.** Table 5 shows the results of a repeated-measures ANCOVA for PWB and subjective vitality. While

TABLE 2: Descriptive statistics by group at pretest and posttest.

Variable	<i>n</i>	Pretest		Posttest	
		Mean	SD	Mean	SD
Total PA (MET-min/week)					
WeActive	43	1283.65	1179.04	1770.48	1546.43
WeMindful	28	1150.02	1052.89	1553.73	901.388
Vigorous PA (MET-min/week)					
WeActive	43	559.07	760.53	736.74	883.078
WeMindful	28	341.14	577.61	568.57	700.675
Moderate PA (MET-min/week)					
WeActive	43	195.81	296.06	390.23	766.332
WeMindful	28	214.29	302.48	187.86	175.317
Walking (MET-min/week)					
WeActive	43	528.77	501.43	643.50	594.033
WeMindful	28	594.59	914.03	797.30	634.689
Psychological well-being					
WeActive	43	12.05	5.10	11.58	4.851
WeMindful	28	9.93	3.99	11.93	5.497
Vitality					
WeActive	43	3.90	1.40	4.06	1.369
WeMindful	28	3.85	1.12	4.16	1.428

TABLE 3: Percentage of participants by group who are “high,” “moderate,” and “low” active at baseline and posttest.

PA level	Group	Pre	Post
High	WeActive	12%	19%
	WeMindful	7%	11%
Moderate	WeActive	56%	60%
	WeMindful	61%	79%
Low	WeActive	33%	21%
	WeMindful	32%	11%

controlling for psychological services attended, repeated-measures ANCOVA showed that there was no significant main effect of group and of time for PWB. However, there was a significant interaction between time and group for PWB ( $F = 11.26, p = 0.001, \eta^2 = 0.022$ ).

Figure 1 displays the interaction effect for PWB scores over time by group. The results indicated that participants in the WeActive group experienced a decrease in PWB scores while participants in the WeMindful group experienced an increase in PWB scores over time.

While controlling for pretest PWB and psychological services attended, a repeated-measures ANCOVA revealed no significant main effect of time and no significant interaction effect of group and time for subjective vitality. However, there was a significant main effect of group for subjective vitality ( $F = 8.91, p = 0.007, \eta^2 = 0.088$ ). Figure 2 displays the main effect of group for subjective vitality. These results indicated that the WeMindful group experienced an overall greater increase in subjective vitality than the WeActive group.

**3.3. Feasibility and Acceptability of the Intervention.** Table 6 displays the mean score by group on the intervention feasibility and acceptability scale. As seen in Table 6, overall, the participants found the intervention to be acceptable, appropriate, and feasible. There were no differences by group in the rating of the feasibility and acceptability of the intervention implementation. Scores for each subscale range from 4 to 20, and the total scale ranges from 12 to 60. Both the WeActive and WeMindful groups rated the feasibility the highest of the three subscales. The total score for both groups was approximately 50 out of 60.

## 4. Discussion

The purpose of this study was to investigate the feasibility and effectiveness of the web-based WeActive and WeMindful interventions in improving physical activity (PA), psychological well-being (PWB), and subjective vitality among college students. Aerobic and resistance training and mindful exercise are popular forms of exercises that have been previously shown to be effective in improving PA and PWB. Moreover, web-based interventions may have helped meet the needs of students during the COVID-19 pandemic.

Both the WeActive and WeMindful groups demonstrated an increase in TPA, VPA, and walking over time. The WeActive group experienced a decrease in PWB scores while the WeMindful group experienced an increase in PWB scores over time. The WeMindful group experienced a greater increase in subjective vitality than the WeActive group. Further, the participants found the intervention to be acceptable, appropriate, and feasible. Although the effect

TABLE 4: Results of a repeated-measures ANOVA for all PA variables.

Effects	Total			Vigorous			Moderate			Walking		
	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$
Group	0.6	0.443	0.005	0.21	0.647	0.002	2.02	0.16	0.018	2.09	0.152	0.018
Therapist	0.56	0.456	0.005	1.82	0.182	0.019	2.15	0.147	0.019	1.01	0.318	0.009
Pre_PWB	4.16	0.045	0.034	4.01	0.049	0.041	1.96	0.166	0.018	1.09	0.3	0.01
Time	7.89	0.006	0.049	5.36	0.024	0.022	2.22	0.14	0.013	7.34	0.009	0.042
Time * group	0.41	0.526	0.003	0.07	0.787	<0.001	0.14	0.711	<0.001	0.01	0.931	<0.001
Time * therapist	2.53	0.116	0.016	0.07	0.794	<0.001	0.22	0.639	0.001	3.16	0.08	0.019
Time * pre_PWB	0.02	0.882	<0.001	0.07	0.789	<0.001	0.04	0.841	<0.001	0.08	0.773	<0.001

TABLE 5: Results of a repeated-measures ANOVA for psychological well-being (PWB) and vitality.

Effects	PWB			Vitality		
	<i>F</i>	<i>p</i>	$\eta^2$	<i>F</i>	<i>p</i>	$\eta^2$
Group	0.02	0.89	<0.001	8.91	0.007	0.088
Therapist	4.46	0.038	0.054	3.1	0.083	0.032
Pre_PWB	—	—	—	120.75	0.001	0.565
Time	1.13	0.292	0.002	1.99	0.163	0.008
Time * group	11.26	0.001	0.022	0.9	0.345	0.004
Time * therapist	4.34	0.041	0.009	1.09	0.083	0.013
Time * pre_PWB	—	—	—	1.42	0.238	0.006

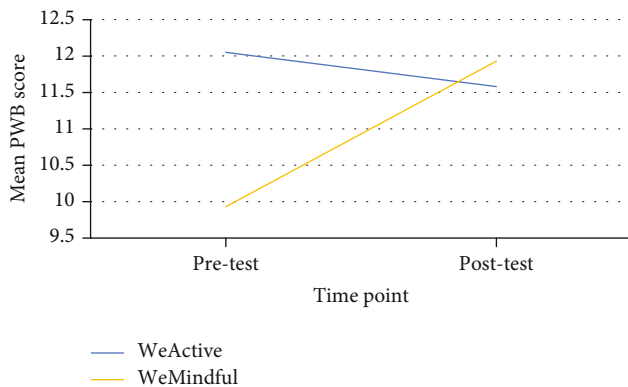


FIGURE 1: Interaction effect for psychological well-being (PWB) scores from pretest to posttest by group.

sizes were small, even modest increases in PA, PWB, and subjective vitality have shown to provide health benefits [55–57].

As hypothesized, the WeActive group experienced an increase in TPA, VPA, and walking after the 8-week intervention. However, we did not expect an increase in PA for the WeMindful group; specifically, we did not expect an increase in VPA. WeMindful sessions were intended to be low-intensity exercises that were focused on flexibility and balance. Therefore, any increases in VPA would have likely taken place outside of the intervention. It is possible that

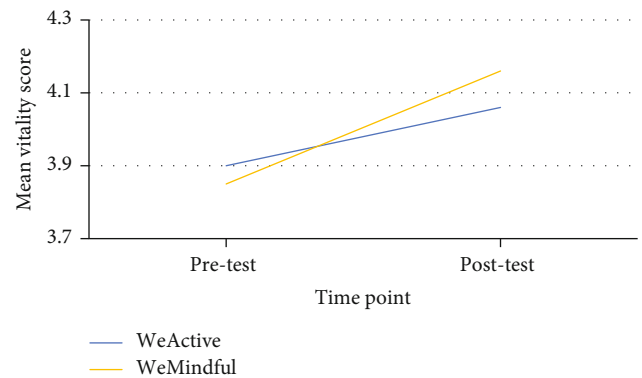


FIGURE 2: Main effect of group for subjective vitality from pretest to posttest.

through participation in mindfulness practices and yoga, students became more aware of their physical bodies and fitness and were more motivated to participate in PA in general, explaining the increase in PA experienced by WeMindful participants from baseline to posttest. In addition, since this intervention took place during the COVID-19 pandemic, there may have been restrictions on gyms and exercise activities at the start of the intervention that may have been lifted towards the end of the intervention, allowing for greater exercise participation in general. Further, previous studies using behavior change techniques such as self-monitoring and self-regulation have been shown to be effective in promoting and maintaining PA [49]. Our study utilized these methods in the peer coaching sessions, such as goal-setting and self-reflection, each week to help achieve meaningful change over the course of the 8-week intervention.

The mindful exercise intervention in this study primarily consisted of yoga-based practices with short mindfulness meditations at the beginning and end of each session. Previous studies have found that college students randomly assigned to either a yoga-only or mindfulness 8-week intervention experienced similar benefits in terms of improvement in depressive, anxiety, and stress symptoms from baseline to follow-up in both conditions [58]. Our findings of an increase in PWB after a mindful exercise intervention are consistent with previous research. A study of 30 students aged 18 to 22 found a significant increase in PWB after a yoga intervention that consisted of a one-hour practice for



TABLE 6: Means and SD of intervention feasibility by total score and subscale by group.

	Acceptability		Appropriateness		Feasibility		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
WeActive	15.85	2.60	15.95	2.60	17.47	2.28	50.12	6.40
WeMindful	15.93	2.34	15.93	2.34	17.36	1.93	49.64	6.38

30 sessions [59]. Medical students who participated in a 6-week yoga and meditation intervention found significant improvement in hedonic aspects of well-being, such as happiness, positivity, and satisfaction [60]. However, our findings that the WeActive participants experienced a decrease in PWB are inconsistent with other findings. PA has been found to be positively related to PWB in college students [16, 61]. Research by Herbert and colleagues found that 6-week low to moderate aerobic exercise intervention conducted with college studies found significant improvements in self-reported mental health, even during stressful periods such as exams [38].

However, there are studies that show a difference in PWB or related mental health constructs when comparing participant outcomes after engaging in either a mindful exercise condition or aerobic exercise condition. A study on adults aged 18-49, who participated first in a one-hour yoga session, then completed a one-hour aerobic exercise session a week later, found that participants experienced a significant decrease in anxiety after the yoga class, but not after the aerobic exercise session [62]. Research has shown that older adults who regularly participated in either yoga or Tai Chi at least one 60-minute session per week experienced better mood and mental health when compared with older adults who regularly participated in a 60-minute aerobic exercise class [63]. Further, it has been previously reported that college students who participated in yoga experienced lower levels of anxiety, depression, tension, anger, and confusion than participants in swimming, body conditioning, fencing, or lecture-control conditions [64]. Still, some other studies have reported no differences in PWB and related constructs between mindful exercise and aerobic or resistance training activities. A study of the effects of a 90-minute mindful exercise session compared to a 90-minute aerobic exercise session on mood found that both mindful exercise and aerobic activities enhanced mood and subjective well-being after a single session among 322 females [65]. Conversely, another study of college students enrolled in a 4-week program where students attended seven 30-minute exercise classes that consisted of activities such as yoga and dancing found no significant increase in PWB [66]. Due to these inconsistencies in the research, further exploration of the relationship between PWB and different types of exercise conditions is warranted.

Our study found a greater improvement in subjective vitality in the WeMindful group than in the WeActive group. This is supported by other research that has found an increase in vitality after mindful exercise interventions. A randomized control trial on 109 graduate students found that participants who received a 25-minute yoga-based practice twice a week over seven weeks had greater increases in

their subjective vitality scores when compared to a control group [67]. A study on 30 college students who participated in mindful exercise (Tai Chi) twice per week for 3 months found an increase in vitality and mental health when compared to their baseline scores [68]. Mindful exercises, such as yoga, appear to positively influence subjective vitality.

The strengths of this study are that both Zoom-based interventions were appropriate, acceptable, and feasible for college students to participate, with an average overall rating of approximately 50 out of 60 possible points. Understanding participants' perception of the Zoom-based intervention is essential to recognizing where implementation may have succeeded or failed and determining the fit of the intervention to the current context. An additional strength of this study was flexible options in terms of participation. Weekly lessons were offered live for participants to attend. Lessons were also recorded and immediately uploaded to the study site where participants could access the videos at any time if they were unable to attend the live session. The study team also sent reminders to complete the exercise sessions, which has been shown to improve effectiveness in virtual interventions [47]. Web-based interventions have the ability to reach a wider population due to increased access to the internet. At the time of this study, data show that 93% of American adults are able to use the internet [69]. Further, there is a relatively low cost to implementing web-based interventions and there is greater convenience to materials due to the unlimited access to the study website. Virtual interventions may prove to be an effective and innovative avenue of promoting positive health behaviors.

There are several limitations to note as well. This study is limited to examining the two web-based exercise intervention effects on PA and PWB. However, to better understand the beneficial effects of these exercises on PA and PWB, including a true control group in future studies may be warranted. Further, given the fact that the participants have the flexibility for attending either live or recorded lessons, it was also difficult to determine the fidelity of participants to the study sessions. Attrition is often a concern with internet-based interventions [45]. Therefore, further studies should employ thorough fidelity and attrition measures to inform adherence to study protocol. In addition, the intervention took place during the COVID-19 pandemic which has provided unprecedented challenges worldwide. Changes to participants' self-report scores may have been unduly influenced by the current state of the world. Further limitations include unequal sample sizes and lack of gender or race diversity in the participant groups. Approximately 63% of our sample identified as white, and 65% of our sample identified as cisgender females. Future studies should focus on using objective measures of study variables as well as recruiting a more diverse sample. Research

has shown that females engage in less PA than males and historically there has been a paucity of research on women's PA [70, 71]. Although there may be a gender bias in this study due to the large number of female participants, the results of this study may contribute to the literature by informing how to increase PA in females.

Despite limitations, it is important to note that there are several practical implications from this study. First, this study adds to the growing literature on online interventions and their effectiveness in improving PA and PWB. Secondly, there are likely to be lasting mental and physical health effects due to the pandemic. Results from this study demonstrated that a virtual program can help students increase their PA and that mindful exercise might be particularly effective in improving PWB. Universities should consider providing exercise programs to help promote both the physical and psychological wellness of their students. Finally, the COVID-19 pandemic has revealed the extensive possibilities of virtual learning and connecting. Evidence from this study may provide support for virtual programming that may increase overall accessibility to interventions and overcome some of the limitations found in traditional in-person programs.

## 5. Conclusion

To conclude, the WeActive and WeMindful interventions were effective in increasing PA among participants in both groups. Further, the WeMindful group experienced an increase in PWB while the WeActive group reported a decrease in PWB over time. Finally, the WeMindful group experienced a greater increase in subjective vitality when compared to the WeActive group. Participants found the intervention to be acceptable, appropriate, and feasible. This study demonstrated that mindful exercise is effective in increasing PA, PWB, and subjective vitality while aerobic and strength training may only be effective in increasing PA. Further research is warranted to explore the different effects of aerobic and strength training when compared to mindful exercises on well-being and subjective vitality.

## Data Availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to restrictions, e.g., they are containing information that could compromise the privacy of research participants.

## Conflicts of Interest

The authors declare that there are no conflicts of interest.

## Acknowledgments

The authors would like to thank all of those who participated in the study as well as the intervention instructors who went above and beyond in their efforts to help make this study a success.

## References

- [1] K. Zivin, D. Eisenberg, S. E. Gollust, and E. Golberstein, "Persistence of mental health problems and needs in a college student population," *Journal of Affective Disorders*, vol. 117, no. 3, pp. 180–185, 2009.
- [2] S. K. Lipson, E. G. Lattie, and D. Eisenberg, "Increased rates of mental health service utilization by U.S. college students: 10-year population-level trends (2007–2017)," *Psychiatric Services*, vol. 70, no. 1, pp. 60–63, 2019.
- [3] J. Hunt and D. Eisenberg, "Mental health problems and help-seeking behavior among college students," *The Journal of Adolescent Health*, vol. 46, no. 1, pp. 3–10, 2010.
- [4] R. Misra and M. McKean, "College students' academic stress and its relation to their anxiety, time management, and leisure satisfaction," *American Journal of Health Studies*, vol. 16, no. 1, pp. 41–51, 2000.
- [5] P. B. Sparling and B. Phillip, "College physical education: an unrecognized agent of change in combating inactivity-related diseases," *Perspectives in Biology and Medicine*, vol. 46, no. 4, pp. 579–587, 2003.
- [6] C. D. Ryff, "Psychological well-being revisited: advances in the science and practice of eudaimonia," *Psychotherapy and Psychosomatics*, vol. 83, no. 1, pp. 10–28, 2014.
- [7] E. L. Cowen, "In pursuit of wellness," *The American Psychologist*, vol. 46, no. 4, pp. 404–408, 1991.
- [8] C. D. Ryff, "Psychological well-being in adult life," *Current Directions in Psychological Science*, vol. 4, no. 4, pp. 99–104, 1995.
- [9] R. M. Ryan and E. L. Deci, "On happiness and human potentials: a review of research on hedonic and eudaimonic well-being," *Annual Review of Psychology*, vol. 52, no. 1, pp. 141–166, 2001.
- [10] B. R. Psychosocial, *Well-being*, N. A. Pachana, Ed., Encyclopedia of Geropsychology, Springer Singapore, 2016.
- [11] R. M. Ryan and C. Frederick, "On energy, personality, and health: subjective vitality as a dynamic reflection of well-being," *Journal of Personality*, vol. 65, no. 3, pp. 529–565, 1997.
- [12] S. Edwards, "Physical exercise and psychological well-being," *South African Journal of Psychology*, vol. 36, no. 2, pp. 357–373, 2006.
- [13] P. C. Dinas, Y. Koutedakis, and A. D. Flouris, "Effects of exercise and physical activity on depression," *Irish Journal of Medical Science*, vol. 180, no. 2, pp. 319–325, 2011.
- [14] W. Chen, "Association of positive psychological wellbeing and BMI with physical and mental health among college students," *Biomedical Journal of Scientific & Technical Research*, vol. 1, no. 4, 2017.
- [15] H. P. H. Chow, "Psychological well-being and scholastic achievement among university students in a Canadian Prairie City," *Social Psychology of Education*, vol. 10, no. 4, pp. 483–493, 2007.
- [16] Z. Zhang, Z. He, and W. Chen, "The relationship between physical activity intensity and subjective well-being in college students," *Journal of American College Health*, vol. 21, pp. 1–6, 2020.
- [17] K. Gebel, D. Ding, T. Chey, E. Stamatakis, W. J. Brown, and A. E. Bauman, "Effect of moderate to vigorous physical activity on all-cause mortality in middle-aged and older Australians," *JAMA Internal Medicine*, vol. 175, no. 6, p. 970, 2015.

- [18] T. Nakagawa, I. Koan, C. Chen et al., "Regular moderate- to vigorous-intensity physical activity rather than walking is associated with enhanced cognitive functions and mental health in young adults," *International Journal of Environmental Research and Public Health*, vol. 17, no. 2, p. 614, 2020.
- [19] M. Small, L. Bailey-Davis, N. Morgan, and J. Maggs, "Changes in eating and physical activity behaviors across seven semesters of college: living on or off campus matters," *Health Education & Behavior*, vol. 40, no. 4, pp. 435–441, 2013.
- [20] R. E. Rhodes, I. Janssen, S. S. D. Bredin, D. E. R. Warburton, and A. Bauman, "Physical activity: health impact, prevalence, correlates and interventions," *Psychology & Health*, vol. 32, no. 8, pp. 942–975, 2017.
- [21] F. W. Booth, C. K. Roberts, and M. J. Laye, "Lack of exercise is a major cause of chronic diseases," *Comprehensive Physiology*, vol. 2, no. 2, pp. 1143–1211, 2012.
- [22] F. Ghorbani, R. Heidaramoghadam, M. Karami, K. Fathi, V. Minasian, and M. E. Bahram, "The effect of six-week aerobic training program on cardiovascular fit-ness, body composition and mental health among female students," *J Res Health Sci.*, vol. 14, no. 4, pp. 264–267, 2014.
- [23] A. M. Lederer, M. T. Hoban, S. K. Lipson, S. Zhou, and D. Eisenberg, "More than inconvenienced: the unique needs of U.S. college students during the COVID-19 pandemic," *Health Education & Behavior*, vol. 48, no. 1, pp. 14–19, 2021.
- [24] M. H. E. M. Browning, L. R. Larson, I. Sharaievska et al., "Psychological impacts from COVID-19 among university students: risk factors across seven states in the United States," *PLoS One*, vol. 16, no. 1, article e0245327, 2021.
- [25] R. M. Holm-Hadulla and A. Koutsoukou-Argraki, "Mental health of students in a globalized world: prevalence of complaints and disorders, methods and effectivity of counseling, structure of mental health services for students," *Mental Health & Prevention*, vol. 3, no. 1, pp. 1–4, 2015.
- [26] A. López-Valenciano, D. Suárez-Iglesias, M. A. Sanchez-Lastra, and C. Ayán, "Impact of COVID-19 pandemic on university students' physical activity levels: an early systematic review," *Frontiers in Psychology*, vol. 11, 2021.
- [27] F. B. Schuch, R. A. Bulzing, J. Meyer et al., "Associations of moderate to vigorous physical activity and sedentary behavior with depressive and anxiety symptoms in self-isolating people during the COVID-19 pandemic: a cross-sectional survey in Brazil," *Psychiatry Research*, vol. 292, p. 113339, 2020.
- [28] G. Maugeri, P. Castrogiovanni, G. Battaglia et al., "The impact of physical activity on psychological health during Covid-19 pandemic in Italy," *Heliyon*, vol. 6, no. 6, article e04315, 2020.
- [29] C. Son, S. Hegde, A. Smith, X. Wang, and F. Sasangohar, "Effects of COVID-19 on college students' mental health in the United States: interview survey study," *Journal of Medical Internet Research*, vol. 22, no. 9, article e21279, 2020.
- [30] D. Eisenberg, M. F. Downs, E. Golberstein, and K. Zivin, "Stigma and help seeking for mental health among college students," *Medical Care Research and Review*, vol. 66, no. 5, pp. 522–541, 2009.
- [31] C. M. Adams and A. Puig, "Incorporating yoga into college counseling," *Journal of Creativity in Mental Health*, vol. 3, no. 4, pp. 357–372, 2008.
- [32] J. Kabat-Zinn, "Mindfulness-based interventions in context: past, present, and future," *Clinical Psychology: Science and Practice*, vol. 10, no. 2, pp. 144–156, 2003.
- [33] N. K. Canby, I. M. Cameron, A. T. Calhoun, and G. M. Buchanan, "A brief mindfulness intervention for healthy college students and its effects on psychological distress, self-control, meta-mood, and subjective vitality," *Mindfulness*, vol. 6, no. 5, pp. 1071–1081, 2015.
- [34] V. Lemay, J. Hoolahan, and A. Buchanan, "Impact of a yoga and meditation intervention on students' stress and anxiety levels," *American Journal of Pharmaceutical Education*, vol. 83, no. 5, 2019.
- [35] I. Ivtzan and A. Papantoniou, "Yoga meets positive psychology: examining the integration of hedonic (gratitude) and eudaimonic (meaning) wellbeing in relation to the extent of yoga practice," *Journal of Bodywork and Movement Therapies*, vol. 18, no. 2, pp. 183–189, 2014.
- [36] R. Gaskins, E. Jennings, H. Thind, B. Becker, and B. Bock, "Acute and cumulative effects of Vinyasa yoga on affect and stress among college students participating in an eight-week yoga program: a pilot study," *International Journal of Yoga Therapy*, vol. 24, no. 1, pp. 63–70, 2014.
- [37] W. Xu, I. R. Kumar, and T. M. Srinivasan, "Evaluation of impact of ethics of yoga in the psychological health of college students: a randomized control trial," *Indian Journal of Science and Technology*, vol. 14, no. 12, pp. 995–1005, 2021.
- [38] C. Herbert, F. Meixner, C. Wiebking, and V. Gilg, "Regular physical activity, short-term exercise, mental health, and well-being among university students: the results of an online and a laboratory study," *Frontiers in Psychology*, vol. 11, 2020.
- [39] E. L. Mailey, T. R. Wójcicki, R. W. Motl et al., "Internet-delivered physical activity intervention for college students with mental health disorders: a randomized pilot trial," *Psychology, Health & Medicine*, vol. 15, no. 6, pp. 646–659, 2010.
- [40] M. A. White, S. D. Whittaker, A. M. Gores, and D. Allswede, "Evaluation of a self-care intervention to improve student mental health administered through a distance-learning course," *American Journal of Health Education*, vol. 50, no. 4, pp. 213–224, 2019.
- [41] A. A. Delextrat, S. Warner, S. Graham, and E. Neupert, "An 8-week exercise intervention based on zumba improves aerobic fitness and psychological well-being in healthy women," *Journal of Physical Activity & Health*, vol. 13, no. 2, pp. 131–139, 2016.
- [42] P. J. O'Connor, M. P. Herring, and A. Carvalho, "Mental health benefits of strength training in adults," *American Journal of Lifestyle Medicine*, vol. 4, no. 5, pp. 377–396, 2010.
- [43] R. Serra, School of Physical Education, Sports of the Federal University of Rio de Janeiro et al., "Resistance training and its impact on psychological health in participants of corporate wellness programs," *International Journal of Sport, Exercise and Health Research*, vol. 1, no. 1, 2017.
- [44] C. Vandelandotte, K. M. Spathonis, E. G. Eakin, and N. Owen, "Website-delivered physical activity interventions: a review of the literature," *American Journal of Preventive Medicine*, vol. 33, no. 1, pp. 54–64, 2007.
- [45] R. P. Joseph, N. H. Durant, T. J. Benitez, and D. W. Pekmezi, "Internet-based physical activity interventions," *American Journal of Lifestyle Medicine*, vol. 8, no. 1, pp. 42–68, 2014.
- [46] W. W. Mak, F. H. Chio, A. T. Chan, W. W. Lui, and E. K. Wu, "The efficacy of internet-based mindfulness training and cognitive-behavioral training with telephone support in the enhancement of mental health among college students and young working adults: randomized controlled trial," *Journal of Medical Internet Research*, vol. 19, no. 3, article e6737, 2017.



- [47] S. Liu, C. Husband, H. La et al., "Development of a self-guided web-based intervention to promote physical activity using the multi-process action control framework," *Internet Interventions*, vol. 15, pp. 35–42, 2019.
- [48] J. R. D. McIntosh, S. Jay, N. Hadden, and P. J. Whittaker, "Do E-health interventions improve physical activity in young people: a systematic review," *Public Health*, vol. 148, pp. 140–148, 2017.
- [49] G. B. Samdal, G. E. Eide, T. Barth, G. Williams, and E. Meland, "Effective behaviour change techniques for physical activity and healthy eating in overweight and obese adults; systematic review and meta-regression analyses," *International Journal of Behavioral Nutrition and Physical Activity*, vol. 14, no. 1, p. 42, 2017.
- [50] International Physical Activity Questionnaire (IPAQ), *SNAP Education Connection*, 2021, <https://snaped.fns.usda.gov/library/materials/international-physical-activity-questionnaire-ipaq>.
- [51] C. W. Topp, S. D. Østergaard, S. Søndergaard, and P. Bech, "The WHO-5 well-being index: a systematic review of the literature," *Psychotherapy and Psychosomatics*, vol. 84, no. 3, pp. 167–176, 2015.
- [52] B. J. Weiner, C. C. Lewis, C. Stanick et al., "Psychometric assessment of three newly developed implementation outcome measures," *Implementation Science*, vol. 12, no. 1, p. 108, 2017.
- [53] P. H. Lee, D. J. Macfarlane, T. H. Lam, and S. M. Stewart, "Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review," *International Journal of Behavioral Nutrition and Physical Activity*, vol. 8, 2011.
- [54] A. Downs, L. A. Boucher, D. G. Campbell, and A. Polyakov, "Using the WHO-5 Well-Being Index to identify college students who are at-risk for mental health problems," *Psychological Sciences Faculty Publications and Presentations*, 2017, [https://pilotscholars.up.edu/psy\\_facpubs/9](https://pilotscholars.up.edu/psy_facpubs/9).
- [55] V. S. Conn, A. R. Hafdahl, and D. R. Mehr, "Interventions to increase physical activity among healthy adults: meta-analysis of outcomes," *American Journal of Public Health*, vol. 101, no. 4, pp. 751–758, 2011.
- [56] N. Howlett, D. Trivedi, N. A. Troop, and A. M. Chater, "Are physical activity interventions for healthy inactive adults effective in promoting behavior change and maintenance, and which behavior change techniques are effective? A systematic review and meta-analysis," *Translational Behavioral Medicine*, vol. 9, no. 1, pp. 147–157, 2019.
- [57] L. A. Weiss, G. J. Westerhof, and E. T. Bohlmeijer, "Can we increase psychological well-being? The effects of interventions on psychological well-being: a meta-analysis of randomized controlled trials," *PLOS ONE*, vol. 11, no. 6, 2016.
- [58] N. Falsafi, "A randomized controlled trial of mindfulness versus yoga: effects on depression and/or anxiety in college students," *Journal of the American Psychiatric Nurses Association*, vol. 22, no. 6, pp. 483–497, 2016.
- [59] P. Akhtar, S. Yardi, and M. Akhtar, "Effects of yoga on functional capacity and well being," *International Journal of Yoga*, vol. 6, no. 1, pp. 76–79, 2013.
- [60] L. Prasad, A. Varrey, and G. Sisti, "Medical students' stress levels and sense of well being after six weeks of yoga and meditation," *Evidence-based Complementary and Alternative Medicine*, vol. 2016, Article ID e9251849, 2016.
- [61] Z. Zhang and W. Chen, "A systematic review of measures for psychological well-being in physical activity studies and identification of critical issues," *Journal of Affective Disorders*, vol. 256, pp. 473–485, 2019.
- [62] D. Winroth, P. Hassmén, and C. Stevens, "Acute effects of yin yoga and aerobic exercise on anxiety," *Altern Integr Med*, vol. 8, p. 278, 2021.
- [63] D. Siddarth, P. Siddarth, and H. Lavretsky, "An observational study of the health benefits of yoga or tai chi compared with aerobic exercise in community-dwelling middle-aged and older adults," *The American Journal of Geriatric Psychiatry*, vol. 22, no. 3, pp. 272–273, 2014.
- [64] B. G. Berger and D. R. Owen, "Stress reduction and mood enhancement in four exercise modes: swimming, body conditioning, hatha yoga, and fencing," *Research Quarterly for Exercise and Sport*, vol. 59, no. 2, pp. 148–159, 1988.
- [65] Y. Netz and R. Lidor, "Mood alterations in mindful versus aerobic exercise modes," *The Journal of Psychology*, vol. 137, pp. 405–419, 2003.
- [66] S. S. Harding, *Be well: a strengths-based approach to increasing physical activity and enhancing wellbeing*, 2021, <http://www.proquest.com/docview/2446705778/abstract/7AB55E1FF483493EPQ/1>.
- [67] C. Dagar, A. Pandey, and A. Navare, "How yoga-based practices build altruistic behavior? Examining the role of subjective vitality, self-transcendence, and psychological capital," *Journal of Business Ethics*, vol. 28, 2020.
- [68] Y. T. Wang, L. Taylor, M. Pearl, and L.-S. Chang, "Effects of tai chi exercise on physical and mental health of college students," *The American Journal of Chinese Medicine*, vol. 32, no. 3, pp. 453–459, 2004.
- [69] *Demographics of internet and home broadband usage in the United States*, Pew Research Center: Internet, Science & Tech, NW 1615 L. St, Suite 800 Washington, Inquiries D 20036USA202-419-4300 | M-857-8562 | F-419-4372 | M, 2021, <https://www.pewresearch.org/internet/fact-sheet/internet-broadband/>.
- [70] M. Segar, T. Jayaratne, J. Hanlon, and C. R. Richardson, "Fitting fitness into women's lives: effects of a gender-tailored physical activity intervention," *Womens Health Issues Off Publ Jacobs Inst Womens Health*, vol. 12, no. 6, pp. 338–347, 2002.
- [71] D. P. Scharff, S. Homan, M. Kreuter, and L. Brennan, "Factors associated with physical activity in women across the life span: implications for program development," *Women & Health*, vol. 29, no. 2, pp. 115–134, 1999.

## Research Article

# Assessment Methods of Body Fat in Recreational Marathon Runners: Bioelectrical Impedance Analysis versus Skinfold Thickness

Pantelis T. Nikolaidis <sup>1,2</sup>, Rodrigo Luiz Vancini <sup>3</sup>, Marília dos Santos Andrade <sup>4</sup>,  
Claudio Andre Barbosa de Lira <sup>5</sup>, and Beat Knechtle <sup>6,7</sup>

<sup>1</sup>School of Health and Caring Sciences, University of West Attica, Egaleo, Greece

<sup>2</sup>Exercise Physiology Laboratory, Nikaia, Greece

<sup>3</sup>Centro de Educação Física e Desportos (CEFD), Universidade Federal do Espírito Santo (UFES), Espírito Santo (ES), Brazil

<sup>4</sup>Departamento de Fisiologia, Universidade Federal de São Paulo (UNIFESP), São Paulo (SP), Brazil

<sup>5</sup>Setor de Fisiologia Humana e do Exercício, Faculdade de Educação Física e Dança, Universidade Federal de Goiás (UFG), Goiânia, Goiás (GO), Brazil

<sup>6</sup>Medbase St. Gallen Am Vadianplatz, St. Gallen, Switzerland

<sup>7</sup>Institute of Primary Care, University of Zurich, Zurich, Switzerland

Correspondence should be addressed to Pantelis T. Nikolaidis; pademil@hotmail.com

Received 5 May 2021; Revised 8 September 2021; Accepted 11 September 2021; Published 29 September 2021

Academic Editor: Haichun Sun

Copyright © 2021 Pantelis T. Nikolaidis et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

The aim of the present study was to examine (a) the relationship of body fat (BF) assessed by bioimpedance analysis (BIA) and skinfold thickness (SKF) and (b) the variation of BF by age depending on the assessment method. Participants were 32 women and 134 men recreational marathon runners, who were tested for BF using both assessment methods (BIA and SKF). Rc between BIA and SKF assessment methods was 0.803 (95% CI; 0.640, 0.897) in women and 0.568 (95% CI; 0.481, 0.644) in men. A large main effect of the assessment method on BF was observed ( $p < 0.001$ ,  $\eta^2 = 0.156$ ) with SKF presenting higher BF than BIA by 2.9%. The difference between SKF and BIA was  $3.9 \pm 2.7\%$  (95% confidence intervals, CI; 3.4; 4.3,  $p < 0.001$ ) in men, whereas no difference was found in women ( $-0.9 \pm 2.9\%$ ; 95% CI; -1.9; -0.2,  $p = 0.101$ ). BF correlated with age with small magnitude (BIA,  $r = 0.18$ ,  $p = 0.036$ ; SKF,  $r = 0.23$ ,  $p = 0.007$ ) in men, i.e., the older the age, the higher the BF. A similar trend of moderate magnitude was observed in women for BIA ( $r = 0.45$ ,  $p = 0.011$ ), but not for SKF ( $r = 0.33$ ,  $p = 0.067$ ). In conclusion, practitioners involved in the training of recreational runners would be advised to consider that BIA elicits a lower BF value than the SKF method in men.

## 1. Introduction

Body fat percentage (BF) has been a predictor of race time in marathon runners—with faster times associated with lower BF—and has been routinely monitored in this sport [1–3]. For instance, elite marathon runners with a personal record less than 2 h 10 min were characterized by low BF ( $<10\%$ ) [4], whereas recreational runners with a personal record close to 4 h had BF higher than 15% [5]. An explanation of this relationship of BF with performance might be that adipose

tissue consisted of an excess mass that runners should carry across a long distance increasing the metabolic demands [6]. BF has been widely assessed in marathon runners using skinfold thickness (SKF) in a certain number of anatomical sites, e.g., seven [4, 7] and ten [8] sites. In addition to SKF, BF has also been evaluated using the technique of bioelectrical impedance analysis (BIA) [9].

Little information existed so far about the relationship between measures of BF relying on SKF and BIA in recreational runners. Considering the popularity of SKF [2, 10]

and BIA [11, 12] to evaluate BF and that these methods might be used interchangeably in the context of training monitoring and performance prediction [13], it would be of practical importance for marathon runners and practitioners working with them to be aware of the relationship between SKF and BIA.

A comparison of these measures in ultraendurance swimmers, cyclists, and triathletes indicated higher values of BF in BIA than in SKF [14]. Since both methodological approaches were widely applied in marathon runners [4, 9], knowledge on the relationship between these approaches could provide valuable information to professionals (e.g., exercise physiologists, sport nutritionists, coaches, and trainers); it would be of great practical importance for practitioners to optimize body mass and body composition of their runners. Studying the relationship between BIA and SKF would concern a large number of athletes—of both sexes and of a wide range of age—who might use these assessment methods interchangeably [15]. Thus, the aim of the present research was to investigate (a) the relationship of BF assessed by BIA and SKF and (b) the variation of BF by age and BMI depending on the assessment method.

## 2. Materials and Methods

**2.1. Participants.** Participants were 32 women (age,  $40 \pm 9$  years, height  $162 \pm 7$  cm, and body mass  $58 \pm 8$  kg) and 134 men ( $44 \pm 9$  years,  $176 \pm 6$  cm, and  $77 \pm 9$  kg, respectively) marathon runners, who had responded to a public call through social media. All participants finished the Athens marathon 2017. After having been informed about the procedures of the research, all participants provided written informed consent. Female and male participants had record in marathon race time  $4:34 \pm 0:39$  and  $4:02 \pm 0:44$  h:min, experience in running training  $5.5 \pm 4.6$  and  $6.8 \pm 5.8$  years,  $3.3 \pm 3.6$  and  $5.6 \pm 6.3$  finished marathons, weekly training days  $4.1 \pm 1.5$  and  $4.4 \pm 1.2$ , and weekly training running distance  $47.7 \pm 22.6$  and  $53.2 \pm 21.1$  km, respectively.

**2.2. Procedures.** Height and weight were measured with subjects in minimal clothing and barefoot. A weighing scale HD-351 (Tanita, Arlington Heights, IL, USA) was used for measurement of weight (to the nearest 0.1 kg) and a portable stadiometer (SECA, Leicester, UK) for height (to the nearest 0.1 cm). The thickness of ten SKF (cheek, chin, pectoral, triceps, subscapular, abdomen, chest II, iliac crest, patella, and proximal calf) was measured to the nearest 0.1 mm (Harpenden, West Sussex, UK) [16]. Parizkova's equations (women,  $BF = 39.572 \log X - 61.25$ ; men,  $BF = 22.32 \log X - 29$ ;  $X = \text{sum of 10 SKF}$ ) were used to estimate BF [16]. An exercise physiologist with experience of measuring SKF with an intraclass correlation coefficient higher than 0.99 in over 10,000 subjects performed all assessments including anthropometric characteristics. Considering the excellent intraclass coefficient correlation of the tester, a single assessment was performed for each anatomical site of SKF. Moreover, BF was evaluated by Tanita BC-545 BIA (Tanita, Arlington Heights, IL, USA). Prior to BIA measurement, sex, age, height, and training status (i.e., being athlete or

not) were entered in Tanita BC-545. With regard to the Tanita BC-545 BIA's option of "being athlete or not," the athlete mode was selected for all participants, and consequently, the corresponding training-specific in-built prediction equations were applied. All testing procedures were carried out on a single session and in the same order (height, weight, SKF, and BIA) by the same researcher who had large experience in the assessment of anthropometry and body composition.

**2.3. Statistical and Data Analysis.** All analyses were performed by GraphPad Prism v. 7.0 (GraphPad Software, San Diego, USA) and IBM SPSS v.26.0 (SPSS, Chicago, USA). Statistical significance was set at  $\alpha = 0.05$ . Data were presented as the mean and standard deviations. Lin's concordance correlation coefficient ( $R_c$ ) examined the relationship between BIA and SKF assessment methods, and 95% confidence intervals (CI) were calculated. A between-within analysis of variance (ANOVA) examined the main effects of assessment method (BIA versus SKF) and sex, and their interaction on BF, and eta squared ( $\eta^2$ ) estimated the magnitude of differences. Bland-Altman plots were used to analyze the agreement between SKF and BIA method to assess BF, and Pearson correlation coefficient  $r$  examined the relationship between the difference (SKF minus BIA) and average values  $((SKF + BIA)/2)$  for each sex.

## 3. Results

$R_c$  between BIA and SKF assessment methods was 0.803 (95% CI; 0.640, 0.897) in women and 0.568 (95% CI; 0.481, 0.644) in men (Figure 1). In women, SKF BF and BIA BF did correlate with any training variable ( $|r| \leq 0.22$ ,  $p \geq 0.225$ ). In men, SKF BF and BIA BF correlated with weekly training days ( $r = -0.39$ ,  $p < 0.001$ ;  $r = -0.32$ ,  $p < 0.001$ , respectively) and weekly running distance ( $r = -0.41$ ,  $p < 0.001$ ;  $r = -0.35$ ,  $p < 0.001$ , respectively), but not with the number of finished marathons or years of running training ( $|r| \leq 0.14$ ,  $p \geq 0.116$ ).

The between-within subjects ANOVA showed a large main effect of the assessment method on BF ( $p < 0.001$ ,  $\eta^2 = 0.156$ ) with overall SKF value being higher than BIA by 2.9% (Table 1). A large sex $\times$ assessment method interaction on BF was observed ( $p < 0.001$ ,  $\eta^2 = 0.317$ ) with the difference between SKF's and BIA's BF being higher in men than in women. Particularly, a paired-samples  $t$ -test showed that this difference was  $3.9 \pm 2.7\%$  (95% confidence intervals, CI; 3.4; 4.3,  $p < 0.001$ ) in men, whereas no difference was found in women ( $-0.9 \pm 2.9\%$ ; 95% CI; -1.9; -0.2,  $p = 0.101$ ).

An analysis of Bland-Altman plots indicated a negative relationship between the difference between the two assessment methods and their average value of small magnitude, i.e., the larger the BF, the smaller their difference (Figure 2). BF correlated with age with small magnitude (BIA,  $r = 0.18$ ,  $p = 0.036$ ; SKF,  $r = 0.23$ ,  $p = 0.007$ ) in men, i.e., the older the age, the higher the BF. A similar trend of moderate magnitude was observed in women for BIA ( $r = 0.45$ ,  $p = 0.011$ ), but not for SKF ( $r = 0.33$ ,  $p = 0.067$ )

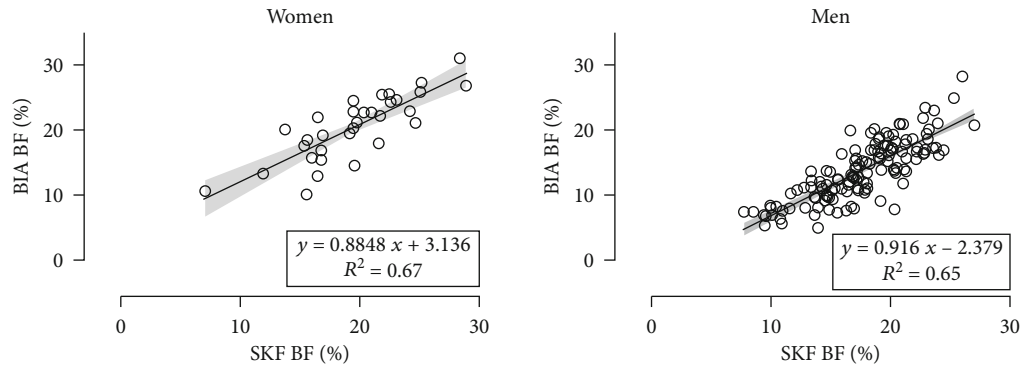


FIGURE 1: Relationship of body fat percentage (BF) estimated by bioelectrical impedance analysis (BIA) and skinfold (SKF) method.  $R^2$  = coefficient of determination.

TABLE 1: Body fat percentage and body mass index by sex.

Variable	Women ( $n = 32$ )	Men ( $n = 134$ )
BMI ( $\text{kg}\cdot\text{m}^{-2}$ )	$21.8 \pm 2.2$	$24.7 \pm 2.6^{**}$
SKF_BF (%)	$19.6 \pm 4.7$	$17.7 \pm 4.0^*$
BIA_BF (%)	$20.5 \pm 5.0$	$13.8 \pm 4.6^{**}$

BMI = body mass index; BF = body fat; SKF = skinfold thickness; BIA = bioelectrical impedance analysis; sex difference at  $*p < 0.05$  and  $**p < 0.001$ .

(Figure 3). The difference between BIA and SKF BF did not correlate with age in women ( $r = -0.25$ ,  $p = 0.176$ ) and men ( $r = 0.04$ ,  $p = 0.667$ ), but it correlated with BMI in men ( $r = -0.26$ ,  $p = 0.002$ ; women,  $r = -0.28$ ,  $p = 0.117$ ).

#### 4. Discussion

The main findings of the present research were that (a) BIA and SKF provided comparable BF in women but differed in men (lower BF in BIA than SKF by ~4%) and (b) age correlated low-to-moderately with BF depending on sex and assessment method. With regard to the role of age in BF, the small-to-moderate magnitude of this relationship might be attributed to long-term adaptations to exercise resulting in attenuation of the increase of BF with age. A recent study showed that men runners ~50 years old had less BMI and BF than a control group [17]. Also, it was found previously that the differences between younger and elder men were greater for visceral fat than for subcutaneous fat [18]. That is, the aging process per se as well as the increase in BF with age can be a key factor in sports performance [19–22]. In addition, the discrepancy between BIA and SKF found in women was in agreement with a previous study [23] confirming a tendency for higher BF in BIA than in SKF with aging.

The evaluation of BIA and SKF elicited comparable values in women, but different in men, where BIA provided the lowest value. The discrepancy of these methods in men should be attributed to variations in hydration status [24] as it has been observed that hydration levels impacted BIA BF [25]. In addition, the reliability of BIA might depend on factors linked to the apparatus, e.g., electrodes and participants [26]. Through Bland-Altman analysis, it was possible

to observe that the SKF and BIA methods were more divergent in individuals presenting low fat mass percentage than in individuals presenting high fat mass. This might justify why the women, who traditionally presented higher BF than men, had lower divergence between the two ways of estimating BF than the men. This observation was in line with a comparison between BIA and SKF in older adults, where women had higher BF than men with both assessment methods and showed a better level of agreement between the methods [27].

The lower value by ~4% of men's BF in BIA than in the SKF method in the present study was in line with research reporting comparable differences in soldiers (~3.5%) [28] and physically active adults (~5.5%) [29], whereas a smaller difference was observed in hikers [30]. A common characteristic of the studies reporting lower BF in BIA than in SKF was that they were conducted on physically active men or athletes [28–30]. On the other hand, there were studies reporting higher BF in BIA than in SKF [31, 32]. For instance, BIA elicited ~6% higher BF than seven-site SKF in young adults [31] and ~2.5% higher BF than SKF in hemodialysis patients [32].

With regard to the limitations of the specific methods of BF evaluation, it was recognized that there were other SKF methods—based on different equations and/or number of anatomical sites—that could elicit different values of BF [33]; similarly, other BIA devices might also differ for the estimation of BF [34] considering the specific prediction algorithms and the technical characteristics of the device. Therefore, the results of this research should be generalized carefully to other assessment tests of body composition. Another limitation of the study might be the unequal sample sizes between female and male participants; however, the variance of values—as indicated by standard deviation of both methods' BF—did not differ by sex suggesting that the assumption of equal variances in ANOVA was not violated. Furthermore, it should be highlighted that the smaller sample size of female than male participants (corresponding to a men-to-women ratio 4.19) was ecologically valid since it reflected the men-to-women ratio observed in several marathon races (e.g., 2.36 in the New York City marathon 1970–2017 [35], 3.86 in the Oslo marathon 2008–2018 [36], and 4.06 in the Athens marathon 2017 [37]). The results might



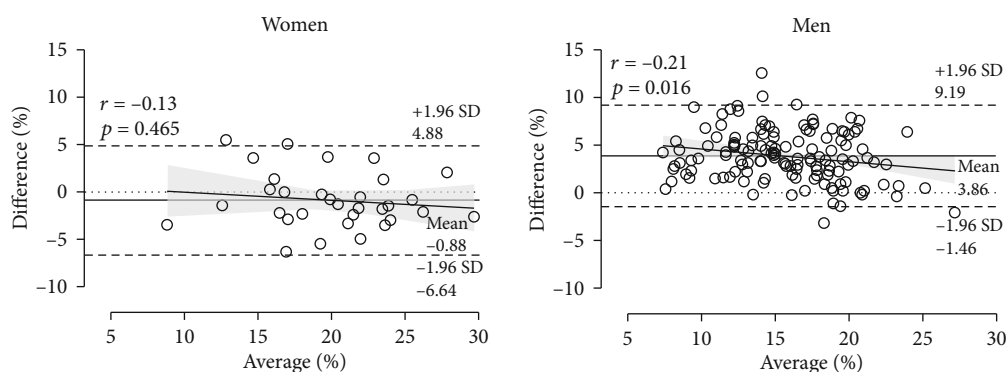


FIGURE 2: Bland-Altman plots showing the difference (bias) between skinfold thickness (SKF) and bioelectrical impedance analysis' (BIA) body fat percentage (BF) (average). Difference = SKF\_BF - BIA\_BF; average = (SKF\_BF + BIA\_BF)/2.

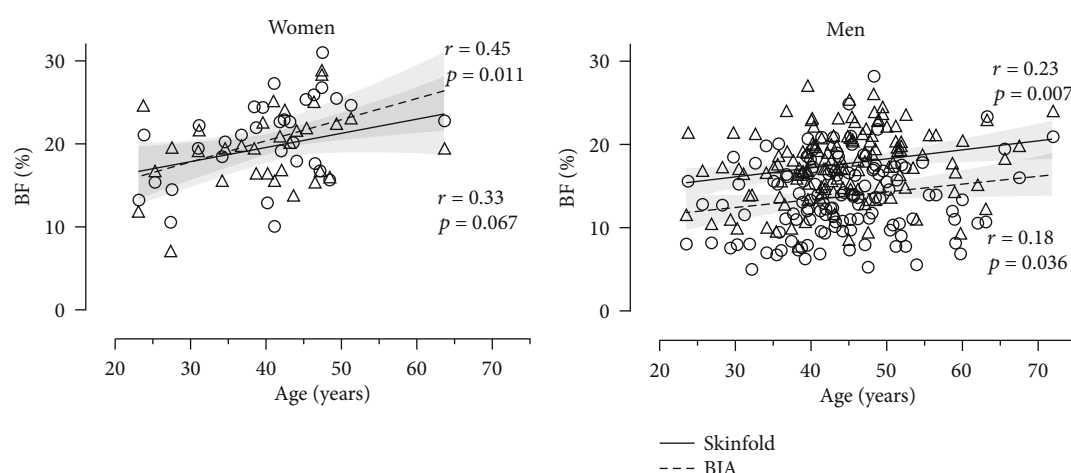


FIGURE 3: Body fat percentage (BF) assessed by skinfold and BIA methods in relation to age.

provide practical information to monitor training in view of the popularity of marathon races [35, 38] and the impact of BF on running performance [2, 39]. However, it should be highlighted that—since neither the one nor the other of the two methods was considered a golden standard of body composition—the present study concerned the comparison of two indirect assessment methods of body fat (SKF and BIA) [40, 41] and was not aimed at validating the one using the other one as reference.

It should be noted that the abovementioned discussion focused on the consideration of mean scores. In this context, the findings of the present study would have practical applications for coaches and fitness trainers working with a group of endurance runners rather than working with a single runner. An analysis of Bland-Altman plots (Figure 2), where the limits of agreement (LoA) provided a measure of agreement at an individual level (i.e., a single runner), showed a relatively large level of agreement (LoA -6.64 to 4.88% in women and -1.46 to 9.19% in men) precluding interchangeability of the two assessment methods at an individual level.

In conclusion, professionals working with recreational runners should consider that bioelectrical impedance analysis might provide lower body fat percentage scores than the

SKF method in men. Therefore, we suggest that practitioners avoid using mixed devices to monitor the effects of training intervention on BF.

## Data Availability

All data are available by P.N. upon reasonable request.

## Ethical Approval

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of Exercise Physiology Laboratory, Nikaia, Greece (EPL 2017/3).

## Consent

Informed consent was obtained from all subjects involved in the study.

## Conflicts of Interest

The authors declare that no conflict of interest exists.

## Authors' Contributions

Conceptualization was performed by P.T.N. and B.K.; methodology was performed by P.T.N. and B.K.; software was secured by P.T.N. and B.K.; validation was performed by P.T.N. and B.K.; formal analysis was performed by P.T.N. and B.K.; investigation was performed by P.T.N. and B.K.; resources were secured by P.T.N. and B.K.; data curation was performed by P.T.N. and B.K.; writing (original draft preparation) was performed by P.T.N., R.L.V., M.S.A., C.A.B.L., and B.K.; writing (review and editing) was performed by P.T.N., R.L.V., M.S.A., C.A.B.L., and B.K.; visualization was performed by P.T.N. and B.K.; supervision was performed by P.T.N. and B.K.; project administration was performed by P.T.N. and B.K.; funding acquisition was performed by P.T.N. and B.K. All authors have read and agreed to the published version of the manuscript.

## References

- [1] J. R. Alvero-Cruz, E. A. Carnero, M. A. G. García et al., "Predictive performance models in long-distance runners: a narrative review," *International Journal of Environmental Research and Public Health*, vol. 17, pp. 1–22, 2020.
- [2] J. J. Salinero, M. L. Soriano, B. Lara et al., "Predicting race time in male amateur marathon runners," *The Journal of sports medicine and physical fitness*, vol. 57, no. 9, pp. 1169–1177, 2017.
- [3] B. Knechtle and G. Tanda, "Effects of training and anthropometric factors on marathon and 100 km ultramarathon race performance," *Open access Journal of Sports Medicine*, vol. 6, pp. 129–136, 2015.
- [4] G. Vernillo, F. Schena, C. Berardelli et al., "Anthropometric characteristics of top-class Kenyan marathon runners," *The Journal of Sports Medicine and Physical Fitness*, vol. 53, pp. 403–408, 2013.
- [5] T. Zillmann, B. Knechtle, C. A. Rüst, P. Knechtle, T. Rosemann, and R. Lepers, "Comparison of training and anthropometric characteristics between recreational male half-marathoners and marathoners," *The Chinese Journal of Physiology*, vol. 56, pp. 138–146, 2013.
- [6] H. Lukaski and C. J. Raymond-Pope, "New frontiers of body composition in sport," *International Journal of Sports Medicine*, vol. 42, no. 7, pp. 588–601, 2021.
- [7] B. Knechtle and G. Tanda, "Marathon performance in relation to body fat percentage and training indices in recreational male runners," *Open access Journal of Sports Medicine*, vol. 4, pp. 141–149, 2013.
- [8] P. T. Nikolaidis and B. Knechtle, "Pacing strategies in the 'Athens classic marathon': physiological and psychological aspects," *Frontiers in Physiology*, vol. 9, p. 1539, 2018.
- [9] M. Marra, A. Di Gregorio, P. Alicante et al., "Evaluation of body composition in competitive male marathon runners," in *Proceedings of the 6th International Congress on Sport Sciences Research and Technology Support*, pp. 158–160, Spain, 2018.
- [10] A. Ogueta-Alday, J. C. Morante, J. Gómez-Molina, and J. García-López, "Similarities and differences among half-marathon runners according to their performance level," *PLoS One*, vol. 13, no. 1, article e0191688, 2018.
- [11] K. Hottenrott, S. Ludyga, and S. Schulze, "Effects of high intensity training and continuous endurance training on aerobic capacity and body composition in recreationally active runners," *Journal of sports science & medicine*, vol. 11, pp. 483–488, 2012.
- [12] P. T. Nikolaidis, C. Knechtle, R. Ramirez-Campillo, R. L. Vancini, T. Rosemann, and B. Knechtle, "Training and body composition during preparation for a 48-hour ultra-marathon race: a case study of a master athlete," *International Journal of Environmental Research and Public Health*, vol. 16, no. 6, p. 903, 2019.
- [13] U. H. Schütz, A. Schmidt-Trucksäss, B. Knechtle et al., "The Transeurope FootRace Project: longitudinal data acquisition in a cluster randomized mobile MRI observational cohort study on 44 endurance runners at a 64-stage 4,486km transcontinental ultramarathon," *BMC Medicine*, vol. 10, no. 1, 2012.
- [14] B. Knechtle, A. Wirth, P. Knechtle, T. Rosemann, C. A. Rust, and R. Bescos, "A comparison of fat mass and skeletal muscle mass estimation in male ultra-endurance athletes using bioelectrical impedance analysis and different anthropometric methods," *Nutricion hospitalaria*, vol. 26, pp. 1420–1427, 2011.
- [15] M. J. Joyner, "Physiological limiting factors and distance Running," *Exercise and Sport Sciences Reviews*, vol. 21, no. 1, pp. 103–133, 1993.
- [16] R. Eston and T. Reilly, "Kinanthropometry and Exercise Physiology Laboratory Manual," in *Tests, Procedures and Data: Volume 1: Anthropometry*, pp. 32–35, Routledge, London, 3rd edition, 2009.
- [17] U. H. Mitchell, B. Bailey, and P. J. Owen, "Examining bone, muscle and fat in middle-aged long-term endurance runners: a cross-sectional study," *Journal of Clinical Medicine*, vol. 9, no. 2, p. 522, 2020.
- [18] P. Szulc, F. Duboeuf, and R. Chapurlat, "Age-Related Changes in Fat Mass and Distribution in Men—the Cross-Sectional STRAMBO Study," *Journal of Clinical Densitometry: The Official Journal of the International Society for Clinical Densitometry*, vol. 20, no. 4, pp. 472–479, 2017.
- [19] P. Jokl, P. M. Sethi, and A. J. Cooper, "Master's performance in the New York City marathon 1983-1999," *British Journal of Sports Medicine*, vol. 38, no. 4, pp. 408–412, 2004.
- [20] R. W. Willy and M. R. Paquette, "The physiology and biomechanics of the master runner," *Sports Medicine and Arthroscopy Review*, vol. 27, no. 1, pp. 15–21, 2019.
- [21] J. Brisswalter and K. Nosaka, "Neuromuscular Factors Associated with Decline in Long-Distance Running Performance in Master Athletes," *Sports medicine*, vol. 43, no. 1, pp. 51–63, 2013.
- [22] H. Tanaka and D. R. Seals, "Invited review: dynamic exercise performance in masters athletes: insight into the effects of primary human aging on physiological functional capacity," *Journal of applied physiology*, vol. 95, pp. 2152–2162, 2003.
- [23] G. Vansant, L. Van Gaal, and I. De Leeuw, "Assessment of Body Composition by Skinfold Anthropometry and Bioelectrical Impedance Technique: A Comparative Study," *Journal of Parenteral and Enteral Nutrition*, vol. 18, no. 5, pp. 427–429, 1994.
- [24] H. C. Lukaski, N. Vega Diaz, A. Talluri, and L. Nescolarde, "Classification of hydration in clinical conditions: indirect and direct approaches using bioimpedance," *Nutrients*, vol. 11, no. 4, p. 809, 2019.

- [25] B. S. Nickerson, R. L. Snarr, and G. A. Ryan, "Bias varies for bioimpedance analysis and skinfold technique when stratifying collegiate male athletes' fat-free mass hydration levels," *Applied Physiology, Nutrition, and Metabolism*, vol. 45, no. 3, pp. 336–339, 2020.
- [26] G. Sergi, M. De Rui, B. Stubbs, N. Veronese, and E. Manzato, "Measurement of lean body mass using bioelectrical impedance analysis: a consideration of the pros and cons," *Aging Clinical and Experimental Research*, vol. 29, no. 4, pp. 591–597, 2017.
- [27] E. A. Silveira, L. S. Barbosa, A. P. S. Rodrigues, M. Noll, and C. De Oliveira, "Body fat percentage assessment by skinfold equation, bioimpedance and densitometry in older adults," *Archives of Public Health*, vol. 78, no. 1, p. 65, 2020.
- [28] W. L. Ripka, C. V. Rotta, L. Ulbricht, and E. B. Neves, "Body composition evaluated by skinfolds and bioimpedance in Brazilian men soldiers," *Revista Internacional de Medicina y Ciencias de la Actividad Fisica y del Deporte*, vol. 14, pp. 279–289, 2014.
- [29] E. Sillanpää, A. Häkkinen, K. Nyman et al., "Body composition and fitness during strength and/or endurance training in older men," *Medicine and Science in Sports and Exercise*, vol. 40, no. 5, pp. 950–958, 2008.
- [30] J. K. Boughman, M. A. Masters, C. A. Morgan, T. M. Ruden, and S. G. Rochelle, "Assessing the validity of bioelectrical impedance and skinfold calipers for measuring body composition in NOLS backcountry hikers," *Wilderness & Environmental Medicine*, vol. 30, no. 4, pp. 369–377, 2019.
- [31] A. D. Wells, B. N. Bellovary, J. M. Houck et al., "New multisite bioelectrical impedance device compared to hydrostatic weighing and skinfold body fat methods," *International Journal of Exercise Science*, vol. 13, pp. 1718–1728, 2020.
- [32] A. M. de Abreu, L. C. Wilvert, and E. Wazlawik, "Comparison of body mass index, skinfold thickness, and bioelectrical impedance analysis with dual-energy X-ray absorptiometry in hemodialysis patients," *Nutrition in Clinical Practice*, vol. 35, no. 6, pp. 1021–1028, 2020.
- [33] C. Leão, M. Camões, F. M. Clemente et al., "Anthropometric profile of soccer players as a determinant of position specificity and methodological issues of body composition estimation," *International Journal of Environmental Research and Public Health*, vol. 16, no. 13, p. 2386, 2019.
- [34] K. L. Vasold, A. C. Parks, D. M. L. Phelan, M. B. Pontifex, and J. M. Pivarnik, "Reliability and validity of commercially available low-cost bioelectrical impedance analysis," *International Journal of Sport Nutrition and Exercise Metabolism*, vol. 29, pp. 1–5, 2019.
- [35] A. Vitti, P. T. Nikolaidis, E. Villiger, V. Onywera, and B. Knechtle, "The "New York City marathon": participation and performance trends of 1.2M runners during half-century," *Research in Sports Medicine*, vol. 28, no. 1, pp. 121–137, 2020.
- [36] P. T. Nikolaidis, I. Cuk, V. J. Clemente-Suárez, E. Villiger, and B. Knechtle, "Number of finishers and performance of age group women and men in long-distance running: comparison among 10km, half-marathon and marathon races in Oslo," *Research in Sports Medicine*, vol. 29, no. 1, pp. 56–66, 2021.
- [37] <https://www.athensauthenticmarathon.gr/site/index.php/en/results-en/491-results-2017-marathon>.
- [38] B. Knechtle, S. Di Gangi, C. A. Rust, and P. T. Nikolaidis, "Performance differences between the sexes in the Boston marathon from 1972 to 2017," *Journal of Strength and Conditioning Research*, vol. 34, no. 2, pp. 566–576, 2020.
- [39] B. Knechtle, Barandun, P. Knechtle et al., "Running speed during training and percent body fat predict race time in recreational male marathoners," *Open access Journal of Sports Medicine*, vol. 3, pp. 51–58, 2012.
- [40] A. M. Kasper, C. Langan-Evans, J. F. Hudson et al., "Come back skinfolds, all is forgiven: a narrative review of the efficacy of common body composition methods in applied sports practice," *Nutrients*, vol. 13, no. 4, p. 1075, 2021.
- [41] S. Y. Lee and D. Gallagher, "Assessment methods in human body composition," *Current Opinion in Clinical Nutrition and Metabolic Care*, vol. 11, no. 5, pp. 566–572, 2008.

## Research Article

# Intensity-Modified Recreational Volleyball Training Improves Health Markers and Physical Fitness in 25–55-Year-Old Men

Goran Vasić<sup>1</sup>,<sup>ID</sup> Nebojša Trajković<sup>2</sup>,<sup>ID</sup> Draženka Mačak<sup>1</sup>,<sup>ID</sup> Tine Sattler,<sup>3</sup> Peter Krstrup<sup>4</sup>,<sup>ID</sup> Nikola Starčević,<sup>5</sup> Goran Sporiš<sup>5</sup>,<sup>ID</sup> and Špela Bogataj<sup>3,6</sup>,<sup>ID</sup>

<sup>1</sup>Faculty of Sport and Physical Education, University of Novi Sad, Novi Sad 21000, Serbia

<sup>2</sup>Faculty of Sport and Physical Education, University of Niš, Niš 18000, Serbia

<sup>3</sup>Faculty of Sport, University of Ljubljana, Ljubljana 1000, Slovenia

<sup>4</sup>Department of Sports Science and Clinical Biomechanics, Faculty of Health Sciences, University of Southern Denmark, Odense 5230, Denmark

<sup>5</sup>Faculty of Kinesiology, University of Zagreb, Zagreb 10110, Croatia

<sup>6</sup>Department of Nephrology, University Medical Centre, Ljubljana 1000, Slovenia

Correspondence should be addressed to Špela Bogataj; [spela.bogataj@kclj.si](mailto:spela.bogataj@kclj.si)

Received 24 March 2021; Revised 31 May 2021; Accepted 3 June 2021; Published 19 June 2021

Academic Editor: Ali Khani jeihooni

Copyright © 2021 Goran Vasić et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

The present study is aimed at determining the effects of intensity-modified recreational volleyball training on health markers and physical fitness in healthy middle-aged men. Thirty-four healthy untrained men aged 25–55 years were randomized to either a modified recreational volleyball group (MRV,  $n = 17$ ) or a recreational volleyball group (RV,  $n = 17$ ). Both groups performed volleyball training twice a week over 12 weeks, with participants in MRV playing a modified game with higher intensity due to shorter breaks between rallies. The small to moderate improvements of both groups were observed in SBP (MRV  $g_{av} = -0.50$  [-0.67, -0.33] vs. RV  $g_{av} = -0.37$  [-0.55, -0.20]) to a similar extent ( $p = 0.12$ ). However, only the MRV significantly improved ( $p < 0.001$ ) the mean body weight ( $g_{av} = -0.35$  [-0.52, -0.18]) and BMI ( $g_{av} = -0.39$  [-0.56, -0.22]) to a moderate extent and the YYIR1 performance ( $g_{av} = 2.45$  [2.22, 2.69]) to a large extent. Even though both groups significantly improved the rest HR, the mean change of rest HR was significantly greater in MRV as compared to the RV ( $p < 0.001$ ,  $\eta_p^2 = 0.47$ ). The study revealed that an intensity-modified type of recreational volleyball, involving shorter breaks between rallies, improves cardiorespiratory fitness and health markers for men aged 25–55 years.

## 1. Introduction

The development of various chronic diseases begins in childhood and adolescence [1–3]. The type of lifestyle we lead therefore determines later quality of life. The importance of physical fitness in promoting quality of life was highlighted in healthy young men [4]. Moreover, it is well documented that cardiorespiratory fitness (CRF) declines with aging in the general population [5] but also among untrained individuals [6]. Considering the fact that low CRF is an important risk factor for cardiovascular and total mortality [7], and that hypertension, diabetes, and hypercholesterolemia as risk factors for cardiovascular disease are influenced by fitness [8, 9],

developing exercise programs which is aimed at improving physical fitness should be one of main objectives of national strategies. Additionally, due to the fact that contexts, content, and purposes of PA are the main condition when health or fitness benefits are addressed different types of exercise programs should be introduced and tested [10]. Team sports (games) have been shown to have a positive impact on physical fitness in the adult population [11, 12]. Furthermore, recreational small-sided football in middle-aged men has resulted in improvements in blood pressure, maximum aerobic power and muscle capillarisation, and enhanced fat oxidation [13–18]. Similar findings were observed for the effect of recreational team handball in a study by Hornstrup et al.



[19]. The authors discovered that a 12-week intervention led to positive muscular, skeletal, and cardiovascular adaptations, with improved maximal oxygen uptake, lower fat percentage, increased muscle enzymatic activity, and improved bone mineralisation [19]. Significant improvements in cardiovascular and musculoskeletal fitness were found after participation in a small-sided recreational basketball program [20]. However, Trajković et al. found that recreational volleyball did not elicit any changes in cardiovascular fitness in healthy middle-aged men [21]. The reason for this may be that the study was conducted on a full court as 6v6.

Volleyball is an intermittent sport, which means it comprises short, high-intensity bouts followed by lower-intensity actions [21]. However, recreational or small-sided volleyball seems to elicit lower average aerobic exercise intensity compared to football, team handball, and other team sports [22–26]. The reasons why lower HRmax is achieved during volleyball may be the high number of mistakes and excessive standing idle during the game. As some studies suggest that the overall fitness and health effects are higher after exercise interventions with predominantly aerobic high-intensity exercise compared to moderate-intensity exercise [14, 23, 27], it appears relevant to focus on the exercise intensity and the fitness effects of various types of volleyball training. Moreover, exercise with higher intensities evoke higher enjoyment than those with lower intensities [28] which is of great importance in identifying effective and time-efficient exercise modalities that would improve fitness and health status in middle-aged adults.

It would therefore be of interest to determine whether the addition of different actions or changes in rules in a recreational volleyball program would elicit better effects due to increased intensity during the game. Rule modifications in football, such as throwing the ball back to the players, together with encouragement from coaches, have been successful at changing the intensity of the game to a certain level [29]. Moreover, recent study showed that modification in sets during SSG may be important for changing intensities during training [30]. As volleyball has a lot of breaks in the game, the idea was to try to shorten the duration of the breaks by throwing the ball back to the players after rallies. Moreover, given the worldwide popularity of volleyball, there is a need for exercise studies using this game as an intervention for improving health and physical fitness. This study is therefore aimed at determining the effects of intensity-modified recreational volleyball on health markers and physical fitness in healthy middle-aged men. We assumed that improvements in physical fitness and most of the health marker variables will occur following the intensity-modified recreational volleyball intervention.

## 2. Materials and Methods

**2.1. Study Design.** This was a pre-post study that was designed to address the question of how a modification in intensity during volleyball program could affect physical fitness and health markers in middle-aged men. To accomplish this, we screened 22–55 years old men and then randomized them according to a computer-generated sequence. The par-

ticipants were randomized in a modified recreational volleyball (MRV) and a recreational volleyball (RV) in order to obtain the correct number of participants for recreational volleyball games. Both groups played recreational volleyball over 12 weeks, with MRV playing an intensity-modified game.

**2.2. Subjects.** Thirty-six healthy untrained men aged 25–55 years agreed to take part in the study after meeting where they were also asked about their history of diseases and medication. The participants were randomly allocated either to a modified recreational volleyball group (MRV,  $n = 17$ ; age,  $43.5 \pm 5.3$  years; height,  $182.3 \pm 7.3$  cm) or a recreational volleyball group (RV,  $n = 17$ ; age,  $41.9 \pm 5.7$  years; height,  $183.8 \pm 6.4$  cm). During the 12-week training program, two subjects withdrew from the study, one due to lack of time and the other due to attending insufficient sessions in the intervention period. Thus, 17 participants remained in each group at final testing (Figure 1). The criteria for inclusion and selection of participants were as follows: male, chronological age 25–55 years, not involved in any type of organised recreational exercise for at least 6 months before the beginning of the program, played volleyball as amateurs and recreationally, and not participating in any other physical exercise program. The criteria for exclusion from the study were as follows: suffering from cardiovascular or respiratory disease, recovering from some form of acute or chronic disease, and in the process of rehabilitation from injury. As all subjects were volunteers, they were able to withdraw from the experimental treatment at any time during the program. Before the beginning of the experimental program, the research and its potential benefits were fully explained to the participants. Additionally, the participants also signed the informed consent statement to take part in the research. The ethical committee approved the study at the Faculty of Sport and Physical Education, University of Novi Sad (Reference No. 46-10-06/2018-5). The study was carried out in accordance with the Declaration of Helsinki.

**2.3. Procedures.** The measurements were performed in the morning in indoor sport hall in the same time and with the same researchers in pre- and posttesting. First, body weight, height, resting heart rate (HR), and blood pressure were measured in a fasting state. Second, participants performed three physical fitness tests in the following order: handgrip strength test, CMJ, and YYIRT1. Participants were asked to refrain from any strenuous activity 48 h prior to all testing and to avoid caffeine 8 h before testing. A standardised warm-up consisting of low intensity running (5 min) and of general exercises such as leg lifts, high skipping, sprints, and lateral running (5 min) was performed before fitness testing. Moreover, a familiarization session was performed for fitness test two days before the testing as well prior to testing.

Body height was measured with a GPM anthropometer (Siber & Hegner, Zurich, Switzerland) to the nearest 0.1 cm. Body weight was measured with a digital scale TANITA BC 540 (TANITA Corp., Arlington Heights, IL) to the nearest 0.01 kg. The following formula was used to calculate body mass index:  $BMI = \text{body mass (kg)} / (\text{height (m)}^2)$ . Upper



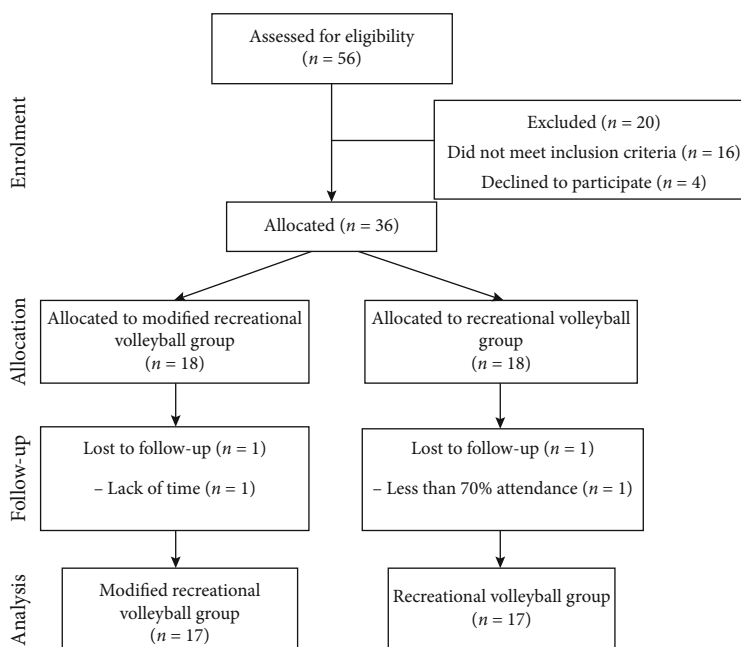


FIGURE 1: Flow diagram of participant enrolment, randomized group allocation, and final analysis.

arm blood pressure monitor (Omron Healthcare, Toronto, Canada) was used to measure blood pressure and resting heart rate. Moreover, the mean arterial blood pressure ( $\text{MAP} = 1/3 \text{ SBP} + 2/3 \text{ DBP}$ ) was used for the analyses. The subject had to be placed comfortably in a sitting position in a quiet room, and after 10 minutes of rest, the cuff of the device was placed on the middle part of the left upper arm.

**2.3.1. Vertical Jump Performance.** Vertical jump performance was tested with countermovement jump (CMJ) without arm swing using an Optojump system (Microgate, Bolzano, Italy). Each participant performed three CMJ repetitions, and the best result, measured in centimeter, was used for further analysis. The validity and reproducibility of vertical jump performance using the Optojump device have proven to be excellent [31, 32]. The CV and the ICC for CMJ were 1.6% and 0.95, respectively.

**2.3.2. Yo-Yo Intermittent Recovery Test Level 1 (YYIR1).** Assessment of the cardiovascular fitness was conducted on an indoor basketball court nearly 1 h following the muscular fitness tests. YYIR1 was developed as a tool to determine cardiovascular fitness [33]. YYIR1 consists of 20 m shuttle runs performed at increasing velocities, with 10 s of active recovery between shuttles, until exhaustion. The player stands beside a cone at the starting line. When the audio device beeps, the player runs to another cone at the turning line 20 m away. When the next beep sounds, the player runs back to the starting line. Upon reaching the starting line, the player has a 10 s recovery period, during which he decelerates to another cone 5 m away and walks back to the starting line. When the next beep sounds, the player repeats the shuttles ( $2 \times 20 \text{ m}$ ). The running speed increases progressively, regulated by the beeps from the audio device. The task is for the player to complete each shuttle before the next beep. The test

stops when the player fails to complete a shuttle twice in a row. The result of the test is the total distance covered up to the last completed shuttle. Additionally, to determine HR values, a short-range telemetric heart rate monitor (S 810, Polar Electro Oy, Kempele, Finland) was placed on the players. We used a 5 s interval recording time to monitor heart rate throughout the test. Post hoc HR analyses were performed using the Polar software (Polar Electro Oy, Kempele, Finland). The peak recorded HR was assumed to be the individual's maximal HR [34].

**2.3.3. Handgrip Strength.** For measuring handgrip strength, a TKK5401 digital dynamometer was used (Takei, Niigata, Japan). The dynamometer measurement was performed with the subject in a standing position, legs spread shoulder-width apart, and arms at the elbows extended along the body. The subject's grip was measured three times with the left hand and three times with the right hand. The results were recorded in kilogram. There was a 1 min resting period between each squeeze to avoid fatigue. The mean value from both hands of the three squeezes was used for further analysis. The CV and ICC for handgrip strength were 1.9% and 0.93, respectively.

**2.3.4. Rating of Perceived Exertion (RPE).** Perception of exertion was evaluated using RPE scores on a 10-point scale [35] collected in all training sessions during the training period.

**2.3.5. Physical Activity Enjoyment Scale (PACES).** We used the revised version of PACES, which consists of 16 statements [36] scored on a 5-point Likert scale ranging from 1 (disagree a lot) to 5 (agree a lot). A high level of enjoyment of physical activity is indicated when high scores on the positive items and low scores on the negative items are obtained. A total enjoyment score can also be obtained by reversing

negative item scores and summing them to positive item scores. With this procedure, total enjoyment scores can range from 16 to 80 (maximum enjoyment). The validity and reliability of PACES were confirmed in adult fitness exercisers [37].

**2.3.6. Training Intervention.** The recreational team volleyball training intervention ran for 12 weeks (Figure 2). During this period, both groups performed two training sessions of ~70 min per week with at least 48 h of rest in between. The participants from the experimental group had one week familiarization with training intervention having in mind the modifications of the rules in volleyball game. No explicit feedback or instructions were given. They were provided with the general instructions and the modifications of the rules. Volleyball experts and assistants were involved in familiarization sessions to ensure that there is stability in playing volleyball according to usual and modified rules. The sessions consisted of a standardised 10 min warm-up followed by 60 min of recreational team volleyball matches (4v4, 5v5, and 6v6), interspersed with two 5-minute breaks. The warm-up comprised 5 min of jogging, running at progressively increasing speeds, and 5 min of technical ball drills (passes). The training sessions took place on an indoor volleyball court (18 × 9 m). The average total training attendance over the 12-week intervention period was  $21 \pm 4$  sessions (MRV =  $22 \pm 3$  and RV =  $20 \pm 4$ ). The difference between the two programs was that MRV had an assistant who delivered the ball to one side of the net or the other after each rally. Having in mind that contacts with the ball are limited in number and duration during volleyball game and that breaks between rallies last from 5.5 to 12 seconds [38], it is of great importance to shorten those breaks, especially during recreational volleyball, where the result is not the primary aim. Moreover, the involvement and encouragement of the assistant were shown to induce the game intensity [39]. The participants in the RV group played a usual volleyball match, with serving after each rally. There was a familiarization session with participants being familiarized with the change of including assistant that throw balls instead of serving. The participants from both groups were asked not to change their usual diet or habitual physical activity apart from the intervention. Heart rate monitoring during sessions was performed using a Polar heart rate monitor (S 810, Polar Electro Oy, Kempele, Finland) once a week. As stated earlier, for all participants, maximal HR was calculated by an YYIRT1 assessment test and based on that the load was determined. Moreover, participants reported RPE and enjoyment immediately after each game.

**2.3.7. Statistical Analysis.** Data are presented as mean  $\pm$  SD unless otherwise stated. The G\*power 3.1 power analysis software determined the minimum sample size ( $N = 22$ ) given the critical  $F = 4.35$ , an effect size  $f = 0.32$  ( $\eta_p^2 = 0.09$ ),  $p = 0.05$ ,  $1 - \beta = 0.8$ , groups and time points = 2, and corr = 0.5. Data are presented as mean  $\pm$  SD unless otherwise stated. Residuals were normally distributed as confirmed by a

Shapiro-Wilk test and a visual inspection of histogram. The Levene's and Box's tests failed to reject homogeneity of variances and covariance matrices, respectively. A  $t$ -test for independent samples determined whether baseline group differences in study outcomes occurred and did the training intensity, RPE, and PACES differ among the groups. A  $2$  (MRV vs. RV)  $\times 2$  (pre vs. posttest) mixed ANOVA evaluated the effects of playing modified recreational volleyball on the study outcomes in respect to traditional recreational volleyball after twelve weeks. Given a treatment\*time interaction effect, we inspected the study outcome mean changes with 95% confidence intervals (95% CIs) from baseline to after 12 weeks depend on whether subjects received the MRV or RV. We consequently estimated a simple main effect of time analyzing mean changes from baseline to after 12 weeks separately for each group with a Bonferroni adjusted  $p$  values and 95% CIs. Partial eta squared ( $\eta_p^2$ ) is reported as the effect size measure for the interaction effects and classified as small (0.01), moderate (0.06), and large (0.14) [40]. The Hedges's  $g_{av}$  with 95% CIs designated the size of simple main effect of time and interpreted as small ( $\pm 0.20$ ), moderate ( $\pm 0.50$ ), and large ( $\pm 0.8$ ). The level of significance was set at  $p \leq 0.05$ . All statistical analyses were performed in the SPSS statistical software (SPSS 23.0, IBM Inc., Chicago, IL, USA).

### 3. Results

**3.1. Training Intensity.** Average training intensity was  $80 \pm 7\%$  HRmax for MRV compared to  $72 \pm 7\%$  HRmax, respectively, for RV ( $p < 0.05$ ; Figure 3). HR distribution in relation to the percentage of training time in target HR zones is presented in Figure 3. Participants spent more time in the heart rate zone 80–90% ( $p < 0.05$ ) during MRV than during RV ( $23.1 \pm 4.3\%$  versus  $13.2 \pm 7.2\%$ ), as well as above 90% ( $p < 0.05$ ;  $15.5 \pm 6.2\%$  versus  $6.4 \pm 3.2\%$ ) (Figure 4). Additionally, average RPE for MRV was  $4.25 \pm 0.24$  compared to  $3.14 \pm 0.24$  for RV. MRV showed a higher score on the PACES enjoyment questionnaire compared to RV ( $73.7 \pm 4.6$  vs.  $70.9 \pm 5.2$ ), but without statistically significant differences.

**3.2. Comparison of Modified (MRV) and Traditional Recreational Volleyball (RV) Effects on Study Outcomes.** Baseline body weight ( $p = 0.76$ ), BMI ( $p = 0.43$ ), rest HR ( $p = 0.50$ ), SBP ( $p = 0.65$ ), DBP ( $p = 0.82$ ), MAP ( $p = 0.73$ ), YYIR1 ( $p = 0.92$ ), handgrip ( $p = 0.74$ ), and CMJ ( $p = 0.69$ ) were similar between the MRV and RV.

The mean body weight and BMI significantly decreased to a moderate extent only in the MRV (Figure 5). The average YYIR1 performance also significantly increased to a large extent only in the MRV (Figure 6). Even though both groups significantly improved rest HR, the mean change of rest HR was significantly greater in MRV than in the RV. However, the small to moderate improvements of SBP were observed in both groups. There were no significant changes in either group for handgrip strength ( $p = 0.60$ ) or CMJ ( $p = 0.15$ ) after the 12-week intervention. Table 1 shows the detailed results from the  $2 \times 2$  ANOVA.

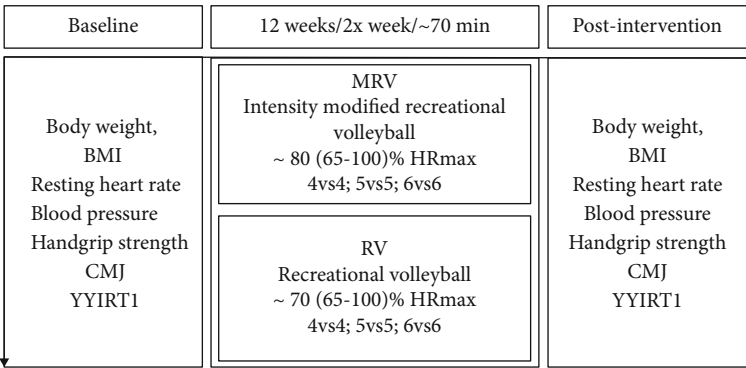


FIGURE 2: Study design.

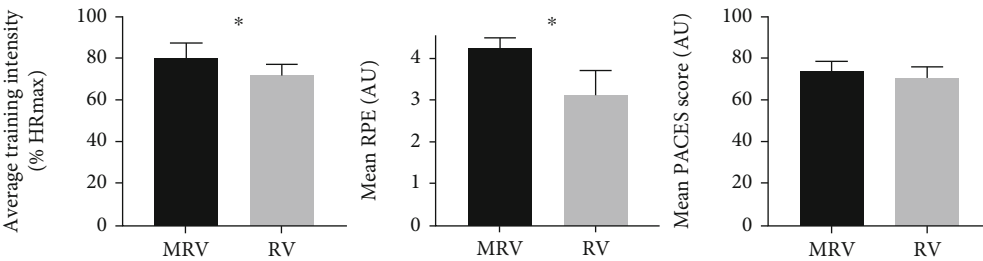


FIGURE 3: Mean heart rate, mean RPE, and mean PACES score in MRV and RV during the intervention. Means  $\pm$  SD are presented. Abbreviations: AU: arbitrary units; MRV: modified recreational volleyball group; PACES: physical activity enjoyment scale; RV: recreational volleyball group. \* $p < 0.05$  significant differences between MRV and RV.

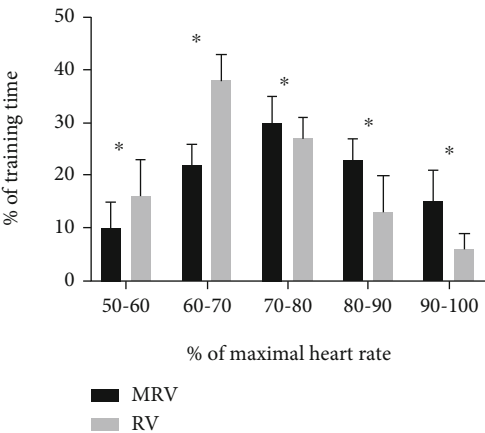


FIGURE 4: Time spent (% of training time) in various heart rate zones as percentage of maximum heart rate (HRmax) during modified recreational volleyball (MRV, black bars) and recreational volleyball (RV, grey bars). Data are presented as means  $\pm$  SD. \* $p < 0.05$  significant differences between MRV and RV.

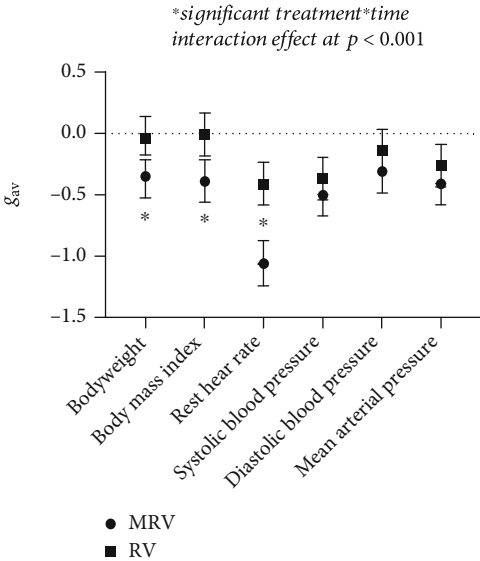


FIGURE 5: Hedges's  $g_{av}$  with 95% CIs on health markers.

4. Discussion

This study is aimed at comparing the effects of modified recreational volleyball and regular recreational volleyball on physical fitness and health markers in healthy middle-aged men. The findings showed that 12 weeks of modified recreational volleyball with higher exercise intensity and higher perceived fun improved cardiorespiratory fitness and

decreased some risk factors, specifically resting HR, body weight, and BMI, compared to regular recreational volleyball. These findings provide support to the hypothesis that the exercise intensity is of importance for the physical fitness and health outcomes of recreational volleyball training.

The YYIRT1 test showed good criterion validity comparing to laboratory  $VO_{2max}$  in recreationally active subjects

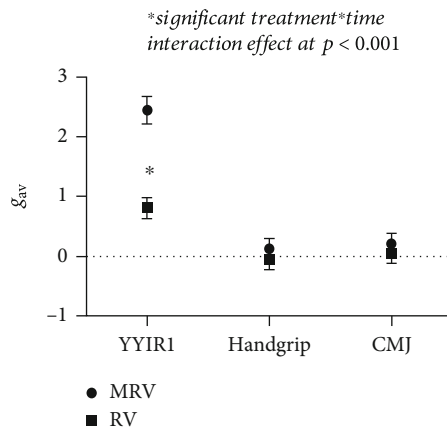


FIGURE 6: Hedges's  $g_{av}$  with 95% CIs on performance of Yo-Yo intermittent recovery test level 1 (YYIR1), handgrip, and countermovement jump (CMJ).

( $r = 0.87$ ) with the reported coefficients of variation of 8.7% [41]. Recent systematic review [42] stated that YYIRT reference values differ regarding the type and level of sport performed. The results in the current study (posttest:  $1064 \pm 92$  m) are somewhat lower compared to reference values from 211 recreationally active adults ( $1339 \pm 53$  m). However, there were no participants that were engaged in recreational volleyball which makes comparison difficult [42]. Nevertheless, the YYIR1 performance had increased markedly in MRV (18.7%) compared to RV (3.3%) after the 12-week intervention ( $g_{av} = 2.45$  [2.22, 2.69], large ES). A similar study found only a 2.4% change (8 m) in YYIR2 performance following 10 weeks of small-sided recreational volleyball practice [43]. Another study [22] conducted on a full court showed that the recreational volleyball group improved shuttle run test performance by 4.3% between pre- and posttests, indicating a small increase in  $VO_2\max$ , while a 3.2% decrease was observed in the control group. Bigger improvements in cardiovascular fitness following modified recreational volleyball training compared to recreational volleyball were mainly due to higher intensity in MRV (80% HRmax versus 72% HRmax) as well as more time spent in higher zones (Figure 3). The higher intensity in modified training/preparatory games compared to regular game conditions has been confirmed in professional volleyball [44]. Recent study showed that the involvement and encouragement of the assistant were shown to change the game intensity [39]. This was confirmed in the current study, where the higher intensity was obtained during a modified volleyball game (Figure 2).

However, besides higher intensity in MRV, the achieved YYIR1 performance change was lower than reported in recreational handball (80%) [25] and recreational football (37–49%) [17] after a similar intervention duration and with similar participants. A recent meta-analysis [17] showed that the intensity of 78–84% HRmax in recreational football is sufficient for the 8–13% improvement in  $VO_2\max$  in healthy untrained men. The results of the current study for cardiorespiratory fitness therefore revealed that MRV represents a

good stimulus for significant improvements after 12 weeks of intervention in healthy middle-aged men.

By contrast, we found no significant changes for countermovement jump performance and handgrip strength after 12 weeks of MRV, with only small improvements compared to RV. As volleyball requires explosive jumps and fast-paced actions [45], it was expected that changes in strength in our study would be somewhat greater. However, the volume of jumps and game intensity in volleyball increase at higher levels [32]. It could be assumed that the great majority of jumps during both types of recreational volleyball were sub-maximal, which may have impacted on our results. Nevertheless, the CMJ results in the current study revealed a tendency for improvement in MRV (+6.2%) compared to RV (+1.7%), albeit these changes did not reach significance. Another possible reason for the small improvements could be the duration of the program. Several studies have shown that longer interventions elicit better improvements in jump performance [13, 46, 47].

The results showed a practical small (+1.2%) improvement in handgrip strength in MRV after 12 weeks. Similar improvements (+3%) were found after recreational handball training in 33–55-year-old sedentary males. Further investigations are warranted, given the importance of handgrip strength and its association with increased risk of cardiovascular and all-cause mortality [48].

Positive effects on cardiovascular risk factors such as resting HR, body weight, and BMI were observed after 12 weeks of modified recreational volleyball. The MRV significantly improved the mean body weight (moderate ES =  $-0.35$  [ $-0.52$ ,  $-0.18$ ]) and BMI (moderate ES =  $-0.39$  [ $-0.56$ ,  $-0.22$ ]). Resting HR is used as an independent noninvasive predictor of cardiovascular diseases [49, 50], since the risk of such illnesses rises with an increase in resting HR above 60 beats per minute (bpm) [51]. The baseline values in our study were higher than 60 bpm, meaning that the more pronounced drop in resting heart rate for the MRV group, may well be of importance for the overall health profile.

Mean diastolic and systolic blood pressure were lowered after the intervention in both groups, with no significant between-group differences. Previous studies have demonstrated that recreational football, handball, floorball, and volleyball successfully decrease blood pressure [13, 19, 22, 52]. Furthermore, the participants in the present study showed higher baseline blood pressure values, so further reductions would be of significant importance bearing in mind that values from 115/75 mmHg increase the risk for cardiovascular diseases [53].

Obesity represents a risk factor for a number of chronic diseases. Our participants had baseline BMI values just above normal ( $25 \text{ kg/m}^2$ ) and can therefore be considered overweight. Hence, a lowering of body weight would be needed to improve health profile. After the intervention period, the participants in MRV had lowered their BMI values, presumably because they were more active and had higher exercise intensity (Figure 2).

The fact that physical activity and nutrition were not fully controlled could be stated as study limitation. This might have affected the training effect on some health markers.

TABLE 1: Comparison of study outcomes among the groups playing modified recreational volleyball (MRV; n=17) and traditional recreational volleyball (RV; n=17) at baseline and after 12 weeks.

Group	Pre-test	Post-test	Mean change [95% CIs]	A2x2 mixed ANOVA: group-by-time interaction effect			
				F <sub>(1, 32)</sub>	p	$\eta_p^2$	1- $\beta$
Bodyweight <sup>‡</sup> (kg)							
MRV	86.33 ± 6.27	84.08 ± 6.04	-2.50 (-2.90,-1.60)**	22.11	<0.001	0.50	0.99
RV	87.00 ± 4.31	86.83 ± 4.15	-0.17 (-0.28, -0.48)				
BMI <sup>‡</sup> (kg/m <sup>2</sup> )							
MRV	26.42 ± 1.63	25.73 ± 1.77	-0.69 (-0.88,-0.50)**	26.27	<0.001	0.54	0.99
RV	25.90 ± 1.50	25.88 ± 1.48	-0.03 (-0.22, 0.16)				
Rest HR <sup>‡</sup> (bpm)							
MRV	67.83 ± 3.38	64.42 ± 2.84	-3.42 (-4.17,-2.67)**	19.32	<0.001	0.47	0.99
RV	68.67 ± 2.57	67.50 ± 2.11	-1.17 (-1.92,-0.42)**				
SBP <sup>‡</sup> (mmHg)							
MRV	133.08 ± 10.16	128.50 ± 7.62	-4.58 (-6.49,-2.67)**	2.56	0.12	0.10	0.33
RV	134.67 ± 6.54	132.17 ± 6.60	-2.50 (-4.41,-0.59)**				
DBP <sup>‡</sup> (mmHg)							
MRV	86.67 ± 4.42	85.25 ± 4.48	-1.42 (-2.47,-0.37)**	1.35	0.26	0.06	0.20
RV	87.08 ± 4.38	86.50 ± 3.78	-0.58 (-1.64, 0.47)				
MAP <sup>‡</sup> (mmHg)							
MRV	102.10 ± 6.11	99.72 ± 5.20	-2.38 (-7.20, 2.20)	3.35	0.08	0.13	0.42
RV	102.89 ± 4.69	101.71 ± 3.97	-1.18 (-4.86, 2.50)				
YYIR1 (m)							
MRV	896.00 ± 40.00	1064.00 ± 92.00	138.00 (128.00,206.00)**	26.19	<0.001	0.58	0.99
RV	898.00 ± 27.00	928.00 ± 44.00	30.00 (-11.00, 71.00)				
Handgrip (kg)							
MRV	51.82 ± 4.60	52.45 ± 4.61	0.64 (-0.56, 1.83)	1.02	0.33	0.05	0.16
RV	52.50 ± 4.70	52.30 ± 4.52	-0.20 (-1.45, 1.05)				
CMJ (cm)							
MRV	33.05 ± 9.87	35.11 ± 8.97	2.06 (-0.52, 4.65)	0.67	0.42	0.03	0.12
RV	34.75 ± 9.06	35.35 ± 9.30	0.60 (-2.11, 3.31)				

Values are Mean±SD. Abbreviations: <sup>‡</sup> reverse scoring; BMI, body mass index; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure; YYIR1, Yo-Yo intermittent recovery test level 1; CMJ, countermovement jump; mean change [95% CIs], mean difference from pre- to post-tests with 95% confidence intervals;  $F(df_{\text{factor}}, df_{\text{error}})$ , F-statistic; p, p value;  $\eta_p^2$ , partial eta squared; 1- $\beta$ , post-hoc statistical power of the test; \*\* significant pre-to post-tests change at  $p < 0.01$ ; \* significant pre-to post change at  $p < 0.05$ .

However, the participants stated that they had their usual diet and were not engaged in any other organised physical activity programs. Moreover, the present study did not use treadmill measurements to evaluate cardiorespiratory fitness, which is considered as important limitation as the results could not be compared with  $\text{VO}_2\text{max}$  reference values. Despite the interest in extending recreational football benefits to other team sports, only two studies [22, 26] involving recreational volleyball have been published in the last five years. These were conducted in order to explore the potential of other team sports in an attempt to find other novel exercise modes that would be as effective as recreational football. However, the results of the abovementioned studies showed that the intensity of recreational volleyball was not high enough to detect significant changes in cardiorespiratory fit-

ness. The current study showed that modified recreational volleyball, with its higher intensity, significantly enhanced cardiorespiratory fitness in middle-aged men. Playing our favourite team sport twice a week for ~1 h with friends therefore has numerous health and social benefits. Another positive factor that could encourage people to engage in recreational volleyball is that it can be played with 4–12 players with no particular demands in respect of facilities, organisation, and a group of committed participants.

## 5. Conclusions

In summary, intensity-modified recreational volleyball training for men aged 25–55 years has a positive impact on physical fitness and health markers. Moreover, the men playing



the modified volleyball game also had high enjoyment scores, emphasizing that the modified version of recreational volleyball appears to be a good tool to optimize the physiological and psychological benefits of volleyball.

## Data Availability

Data available on request.

## Conflicts of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## References

- [1] S. Cook, P. Auinger, and T. T. K. Huang, "Growth curves for cardio-metabolic risk factors in children and adolescents," *The Journal of Pediatrics*, vol. 155, no. 3, pp. S6.e15–S6.e26, 2009.
- [2] N. Halfon, P. A. Verhoef, and A. A. Kuo, "Childhood antecedents to adult cardiovascular disease," *Pediatrics in Review*, vol. 33, no. 2, pp. 51–61, 2012.
- [3] H. W. Kohl III and H. D. Cook, "Physical Activity and Physical Education Relationship to Growth, Development, and Health," in *Educating the Student Body: Taking Physical Activity and Physical Education to School*, National Academies Press (US), 2013.
- [4] A. Häkkinen, M. Rinne, T. Vasankari, M. Santtila, K. Häkkinen, and H. Kyröläinen, "Association of physical fitness with health-related quality of life in Finnish young men," *Health and Quality of Life Outcomes*, vol. 8, no. 1, pp. 1–15, 2010.
- [5] C. L. Ogden, M. D. Carroll, L. R. Curtin, M. M. Lamb, and K. M. Flegal, "Prevalence of high body mass index in US children and adolescents 2007–2008," *Journal of the American Medical Association*, vol. 303, no. 3, pp. 242–249, 2010.
- [6] J. L. Fleg, C. H. Morrell, A. G. Bos et al., "Accelerated longitudinal decline of aerobic capacity in healthy older adults," *Circulation*, vol. 112, no. 5, pp. 674–682, 2005.
- [7] M. R. Carnethon, S. S. Gidding, R. Nehgme, S. Sidney, D. R. Jacobs Jr., and K. Liu, "Cardiorespiratory fitness in young adulthood and the development of cardiovascular disease risk factors," *JAMA*, vol. 290, no. 23, pp. 3092–3100, 2003.
- [8] W. E. Kraus, J. A. Houmard, B. D. Duscha et al., "Effects of the amount and intensity of exercise on plasma lipoproteins," *New England Journal of Medicine*, vol. 347, no. 19, pp. 1483–1492, 2002.
- [9] J. Myers, P. McAuley, C. J. Lavie, J.-P. Despres, R. Arena, and P. Kokkinos, "Physical activity and cardiorespiratory fitness as major markers of cardiovascular risk: their independent and interwoven importance to health status," *Progress in Cardiovascular Diseases*, vol. 57, no. 4, pp. 306–314, 2015.
- [10] S. C. E. Schmidt, S. Tittlbach, K. Börs, and A. Woll, "Different types of physical activity and fitness and health in adults an 18-year longitudinal study," *BioMed Research International*, vol. 2017, Article ID 1785217, 10 pages, 2017.
- [11] M. T. Pedersen, J. Vorup, A. Nistrup et al., "Effect of team sports and resistance training on physical function, quality of life, and motivation in older adults," *Scandinavian Journal of Medicine & Science in Sports*, vol. 27, no. 8, pp. 852–864, 2017.
- [12] C. Castagna, M. de Sousa, P. Krstrup, and D. T. Kirkendall, "Recreational team sports the motivational medicine," *Journal of Sport and Health Science*, vol. 7, no. 2, pp. 129–131, 2018.
- [13] P. Krstrup, P. Aagaard, L. Nybo, J. Petersen, M. Mohr, and J. Bangsbo, "Recreational football as a health promoting activity a topical review," *Scandinavian Journal of Medicine & Science in Sports*, vol. 20, pp. 1–13, 2010.
- [14] P. Krstrup, J. Dvorak, A. Junge, and J. Bangsbo, "Executive summary The health and fitness benefits of regular participation in small-sided football games," *Scandinavian Journal of Medicine & Science in Sports*, vol. 20, pp. 132–135, 2010.
- [15] P. Krstrup and B. R. Krstrup, "Football is medicine: it is time for patients to play," *British Journal of Sports Medicine*, vol. 52, no. 22, pp. 1412–1414, 2018.
- [16] J. Bangsbo, P. R. Hansen, J. Dvorak, and P. Krstrup, "Recreational football for disease prevention and treatment in untrained men: a narrative review examining cardiovascular health, lipid profile, body composition, muscle strength and functional capacity," *British Journal of Sports Medicine*, vol. 49, no. 9, pp. 568–576, 2015.
- [17] Z. Milanović, S. Pantelić, N. Čović, G. Sporiš, and P. Krstrup, "Is recreational soccer effective for improving V O<sub>2</sub>max A systematic review and meta-analysis," *Sports Medicine*, vol. 45, no. 9, pp. 1339–1353, 2015.
- [18] Z. Milanović, S. Pantelić, N. Čović, G. Sporiš, M. Mohr, and P. Krstrup, "Broad-spectrum physical fitness benefits of recreational football: a systematic review and meta-analysis," *British Journal of Sports Medicine*, vol. 53, no. 15, pp. 926–939, 2019.
- [19] T. Hornstrup, F. T. Løwenstein, M. A. Larsen et al. Cardiovascular, muscular, and skeletal adaptations to recreational team handball training: a randomized controlled trial with young adult untrained men," *European Journal of Applied Physiology*, vol. 119, no. 2, pp. 561–573, 2019.
- [20] E. Stojanović, N. Stojiljković, R. Stanković, A. T. Scanlan, V. J. Dalbo, and Z. Milanović, "Recreational basketball small-sided games elicit high-intensity exercise with low perceptual demand," *Journal of Strength and Conditioning Research*, vol. - Publish Ahead of Print, 2019.
- [21] T. Gabbett, B. Georgieff, S. Anderson, B. Cotton, D. Savovic, and L. Nicholson, "Changes in skill and physical fitness following training in talent-identified volleyball players," *Journal of Strength and Conditioning Research*, vol. 20, no. 1, pp. 29–35, 2006.
- [22] N. Trajković, D. Madić, S. Andrašić, and D. Radanović, "Effects of recreational volleyball on health markers in middle-aged men," in *Proceedings of the 14th International Scientific Conference of Sport Kinetics*, 2018.
- [23] P. Krstrup, J. J. Nielsen, B. R. Krstrup et al., "Recreational soccer is an effective health-promoting activity for untrained men," *British Journal of Sports Medicine*, vol. 43, no. 11, pp. 825–831, 2009.
- [24] M. B. Randers, J. J. Nielsen, B. R. Krstrup et al., "Positive performance and health effects of a football training program over 12 weeks can be maintained over a 1-year period with reduced training frequency," *Scandinavian Journal of Medicine & Science in Sports*, vol. 20, Supplement 1, pp. 80–89, 2010.

- [25] S. C. A. Póvoas, C. Castagna, C. Resende et al., "Effects of a short-term recreational team handball-based programme on physical fitness and cardiovascular and metabolic health of 33-55-year-old men: a pilot study," *BioMed Research International*, vol. 2018, Article ID 4109796, 11 pages, 2018.
- [26] N. Trajković, G. Sporiš, T. Krističević, and Š. Bogataj, "Effects of small-sided recreational volleyball on health markers and physical fitness in middle-aged men," *International Journal of Environmental Research and Public Health*, vol. 17, no. 9, p. 3021, 2020.
- [27] L. Nybo, E. Sundstrup, M. D. Jakobsen et al., "High-intensity training versus traditional exercise interventions for promoting health," *Medicine and Science in Sports and Exercise*, vol. 42, no. 10, pp. 1951–1958, 2010.
- [28] J. S. Thum, G. Parsons, T. Whittle, and T. A. Astorino, "High-intensity interval training elicits higher enjoyment than moderate intensity continuous exercise," *PLoS One*, vol. 12, no. 1, p. e0166299, 2017.
- [29] J. Halouani, H. Chtourou, T. Gabbett, A. Chaouachi, and K. Chamari, "Small-Sided Games in Team Sports Training," *Journal of Strength and Conditioning Research*, vol. 28, no. 12, pp. 3594–3618, 2014.
- [30] F. Manuel Clemente, R. Franco Lima, J. Moran et al., "The way to increase the motor and sport competence among children: the contextualized sport alphabetization model," *Frontiers in Physiology*, vol. 10, 2019.
- [31] J. F. Glatthorn, S. Gouge, S. Nussbaumer, S. Stauffacher, F. M. Impellizzeri, and N. A. Maffiuletti, "Validity and reliability of optojump photoelectric cells for estimating vertical jump height," *Journal of Strength and Conditioning Research*, vol. 25, no. 2, pp. 556–560, 2011.
- [32] T. Sattler, V. Hadžić, E. Dervišević, and G. Markovic, "Vertical jump performance of professional male and female volleyball players: effects of playing position and competition level," *Journal of Strength and Conditioning Research*, vol. 29, no. 6, pp. 1486–1493, 2015.
- [33] J. Bangsbo, F. M. Iaia, and P. Krstrup, "The Yo-Yo Intermitent Recovery Test," *Sports Medicine*, vol. 38, no. 1, pp. 37–51, 2008.
- [34] P. Krstrup, M. Mohr, T. Amstrup et al., "The Yo-Yo intermitent recovery test: physiological response, reliability, and validity," *Medicine and Science in Sports and Exercise*, vol. 35, no. 4, pp. 697–705, 2003.
- [35] C. Foster, J. A. Florhaug, J. Franklin et al., "A new approach to monitoring exercise training," *Journal of Strength and Conditioning Research*, vol. 15, no. 1, pp. 109–115, 2001.
- [36] R. W. Motl, R. K. Dishman, R. Saunders, M. Dowda, G. Felton, and R. R. Pate, "Measuring enjoyment of physical activity in adolescent girls," *American Journal of Preventive Medicine*, vol. 21, no. 2, pp. 110–117, 2001.
- [37] P. Teques, L. Calmeiro, C. Silva, and C. Borrego, "Validation and adaptation of the Physical Activity Enjoyment Scale PACES in fitness group exercisers," *Journal of Sport and Health Science*, vol. 9, no. 4, pp. 352–357, 2020.
- [38] D. Mroczek, A. Januszkiewicz, A. S. Kawczyński, Z. Borysiuk, and J. Chmura, "Analysis of male volleyball players motor activities during a top level match," *Journal of Strength and Conditioning Research*, vol. 28, no. 8, pp. 2297–2305, 2014.
- [39] O. Selmi, W. B. Khalifa, N. Ouerghi, F. Amara, and M. Zouaoui, "Effect of verbal coach encouragement on small sided games intensity and perceived enjoyment in youth soccer players," *Journal of Athletic Enhancement*, vol. 6, no. 3, pp. 16–17, 2017.
- [40] J. Cohen, *Statistical Power Analysis for the Behavioral Sciences*, Lawrence Erlbaum Associates, Inc., New York, Second edition, 1988.
- [41] A. Thomas, B. Dawson, and C. Goodman, "The yo-yo test: reliability and association with a 20-m shuttle run and VO<sub>2</sub>max," *International Journal of Sports Physiology and Performance*, vol. 1, no. 2, pp. 137–149, 2006.
- [42] B. Schmitz, C. Pfeifer, K. Kreitz, M. Borowski, A. Faldum, and S.-M. Brand, "The Yo-Yo intermittent tests: a systematic review and structured compendium of test results," *Frontiers in Physiology*, vol. 9, p. 870, 2018.
- [43] N. Trajković, D. Madić, Z. Milanović et al., "Eight months of school-based soccer improves physical fitness and reduces aggression in high-school children," *Biology of Sport*, vol. 37, no. 2, pp. 185–193, 2020.
- [44] M. Lehnert, P. Stejskal, P. Háp, and M. Vavák, "Load intensity in volleyball game like drills," *Acta Universitatis Palackianae Olomucensis*, vol. 38, no. 1, p. 53, 2008.
- [45] A. F. Silva, F. M. Clemente, R. Lima, P. T. Nikolaidis, T. Rosemann, and B. Knechtel, "The effect of plyometric training in volleyball players: a systematic review," *International Journal of Environmental Research and Public Health*, vol. 16, no. 16, p. 2960, 2019.
- [46] M. B. Randers, L. Nybo, J. Petersen et al., "Activity profile and physiological response to football training for untrained males and females, elderly and youngsters: influence of the number of players," *Scandinavian Journal of Medicine & Science in Sports*, vol. 20, Supplement 1, pp. 14–23, 2010.
- [47] M. D. Jakobsen, E. Sundstrup, M. B. Randers et al., "The effect of strength training, recreational soccer and running exercise on stretch-shortening cycle muscle performance during countermovement jumping," *Human Movement Science*, vol. 31, no. 4, pp. 970–986, 2012.
- [48] D. P. Leong, K. K. Teo, S. Rangarajan et al., "Prognostic value of grip strength: findings from the Prospective Urban Rural Epidemiology PURE study," *The Lancet*, vol. 386, no. 9990, pp. 266–273, 2015.
- [49] J. F. Thayer and R. D. Lane, "The role of vagal function in the risk for cardiovascular disease and mortality," *Biological Psychology*, vol. 74, no. 2, pp. 224–242, 2007.
- [50] J. Hsia, J. C. Larson, J. K. Ockene et al., "Resting heart rate as a low tech predictor of coronary events in women: prospective cohort study," *BMJ*, vol. 338, no. 7694, pp. 577–579, 2009.
- [51] K. Fox, J. S. Borer, A. J. Camm et al., "Resting heart rate in cardiovascular disease," *Journal of the American College of Cardiology*, vol. 50, no. 9, pp. 823–830, 2007.
- [52] J. Vorup, M. T. Pedersen, P. S. Melcher, R. Dreier, and J. Bangsbo, "Effect of floorball training on blood lipids, body composition, muscle strength, and functional capacity of elderly men," *Scandinavian Journal of Medicine & Science in Sports*, vol. 27, no. 11, pp. 1489–1499, 2017.
- [53] S. Lewington, R. Clarke, N. Qizilbash, R. Peto, and R. Collins, "Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies," *The Lancet*, vol. 360, no. 9349, pp. 1903–1913, 2002.