Physical fitness in child and adolescent obesity: Evaluation and management

1. **Physical Activity and Fitness in Pediatric Obesity: Terms and definitions**
2. **Assessment of Physical Activity and Fitness in youth with Obesity**
3. **Strategies to improve physical activity and fitness in Pediatric Obesity**

Grace O'Malley (Ireland)

Susanne Ring Dimitriou (Austria)

David Thivel (France)

Authors

Grace O'Malley

Dr. Grace O'Malley is a Clinical Researcher working in the School of Physiotherapy, Division of Population Health Sciences at the Royal College of Surgeons in Ireland. She works clinically as a clinical specialist physiotherapist in paediatrics, at Children's Health Ireland at Temple Street where she leads a multidisciplinary team treating obesity in children and adolescents. Grace completed her PhD in University College Cork studying the evidence-based treatment of childhood obesity and the integration of telemedicine and connected health. Her Msc explored the relationship between obesity and physical fitness in children and adolescents. Grace undertook post-doctoral work in the University of Southern California exploring the use of connected health in obesity and at the University of California (Davis) she studied the use of telemedicine in paediatric healthcare.
Her research investigates the relationship between obesity and physical fitness, the use of connected health in the prevention and management of obesity, the evidence based assessment and treatment of childhood obesity and behavioural economics for the prevention and treatment of chronic disease. Grace is a member of the European Childhood Obesity Group and the Childhood Obesity Task Force (EASO). She is Secretary of the European Association for the Study of Obesity and was inaugural Chair of the Association for the Study of Obesity on the Island of Ireland (ASOI).

Susanne Ring-Dimitriou

Dr Susanne Ring-Dimitriou is associate professor at the Department of Sport Science and Kinesiology at the University of Salzburg. She started her career in Salzburg then completed her PhD at the German Sport University Cologne. She has devoted her career to exercise, physical fitness and health targeting untrained healthy adults and children with metabolic and cardiovascular risks. She is a member of the European College of Sport Science, the Deutsche Vereinigung für Sportwissenschaft (dvs), the Deutsche Adipositas Gesellschaft (DAG), the Österreichische Sportwissenschaftliche Gesellschaft (ÖSG, President 2010-2012) and a board member of the Obesity Academy Austria (OAA). In 2009, she finished her Habilitation (*Physical Fitness and Metabolic Syndrome*) at the University of Salzburg in the field of "Sport Science: Exercise and Health (venia docendi)", where she still works as a researcher and lecturer. Susanne likes moving in the water and has competed professionally as a swimmer.

David Thivel

David Thivel completed his PhD in the Laboratory of Human Nutrition (INRA) and the Laboratory of Biology of APS Clermont-Ferrand (University Blaise Pascal), studying nutritional adaptations to physical exercise in the teenager thin and obese. He completed a first postdoctoral stay at Columbia University in New York City (USA) where he was able to deepen these energetic and metabolic explorations in response to weight loss induced by bariatric surgery. His second postdoctoral fellowship in Ottawa, Canada, allowed him to continue his work on nutritional responses to physical exercise and sedentary behaviours in children.
Today, David is Associate Professor at Clermont Auvergne University in Clermont-Ferrand and focuses his research on the interests and impacts of physical activity and sedentary lifestyle on the metabolic profile and nutritional status of children and adolescents, particularly in the context of pediatric obesity. David is Vice President of ECOG.

Description of the course

The first part of this module addresses definitions and concepts:

- What is physical activity and its main components?
- What do we mean by physical inactivity?
- What about sedentary behaviours?
- Implications in paediatric obesity

The second part focuses on physical fitness in youth with obesity:

- What is physical fitness?
- Is physical fitness impaired in youth with obesity?
- How to assess physical fitness?

The third part presents the main strategies to improve physical activity and fitness in paediatric obesity :

- What are the main principles of physical activity interventions?
- What are the effect of interventions on fitness in children with obesity?

Learning objectives

At the end of this module you should be able to:

1. **Properly differentiate the concepts of physical activity, inactivity and sedentary behaviours**
2. **Understand the main recommendations relevant to children and adolescents with obesity**
3. **Understand the main methods to assess physical fitness**
4. **Better understand the main effects of physical activity interventions on fitness in children with obesity**

E-module from the European Childhood Obesity Group (ECOG) & the World Obesity Federation

PART I

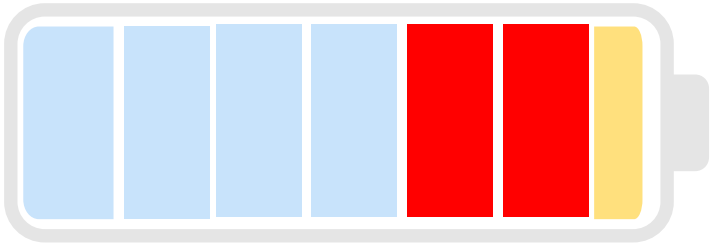
Physical Activity & Fitness in Pediatric Obesity:

Terms and definitions

David Thivel

Physical Activity

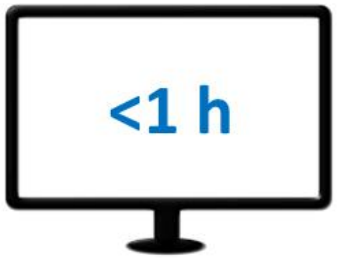
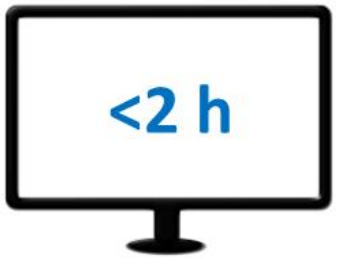
Body Movements generated by skeletal muscle contractions and favoring an increase of energy expenditure > to the Resting Metabolic Rate



100%

Resting Metabolic Rate
Physical Activity EE
Thermic Effect Food
=
Total Energy Expenditure (TEE)

Recommendations

< 6 yo			
5-18 yo			

Body Movements generated by skeletal muscle contractions and favoring an increase of energy expenditure > to the Resting Metabolic Rate

Physical Activity

Physical Inactivity

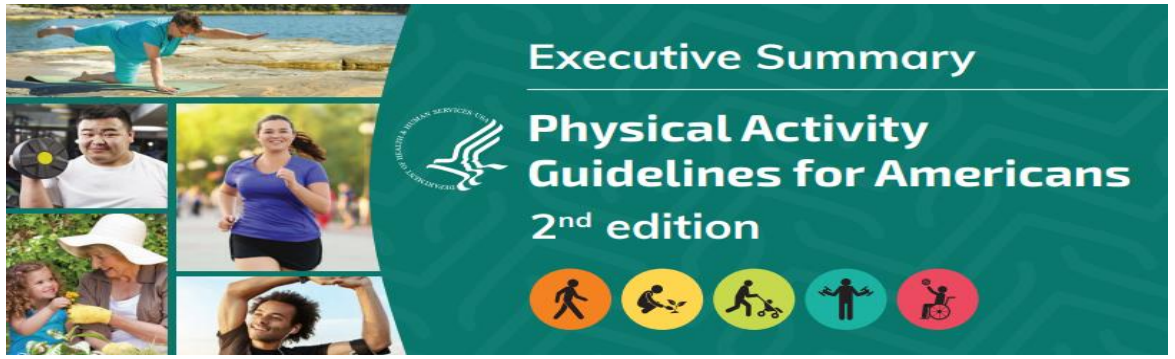
Not reaching Physical activity recommendations

Sedentary Behaviors

Behaviors with EE <1.5 Mets (SBRN)

Tremblay et al., 2011

Recommandations



Key Guidelines for Preschool-Aged Children

- Preschool-aged children (ages 3 through 5 years) should be physically active throughout the day to enhance growth and development.
- Adult caregivers of preschool-aged children should encourage active play that includes a variety of activity types.

Key Guidelines for Children and Adolescents

- It is important to provide young people opportunities and encouragement to participate in physical activities that are appropriate for their age, that are enjoyable, and that offer variety.
- Children and adolescents ages 6 through 17 years should do 60 minutes (1 hour) or more of moderate-to-vigorous physical activity daily:
  - **Aerobic:** Most of the 60 minutes or more per day should be either moderate- or vigorous-intensity aerobic physical activity and should include vigorous-intensity physical activity on at least 3 days a week.
  - **Muscle-strengthening:** As part of their 60 minutes or more of daily physical activity, children and adolescents should include muscle-strengthening physical activity on at least 3 days a week.
  - **Bone-strengthening:** As part of their 60 minutes or more of daily physical activity, children and adolescents should include bone-strengthening physical activity on at least 3 days a week.

European Childhood Obesity Group

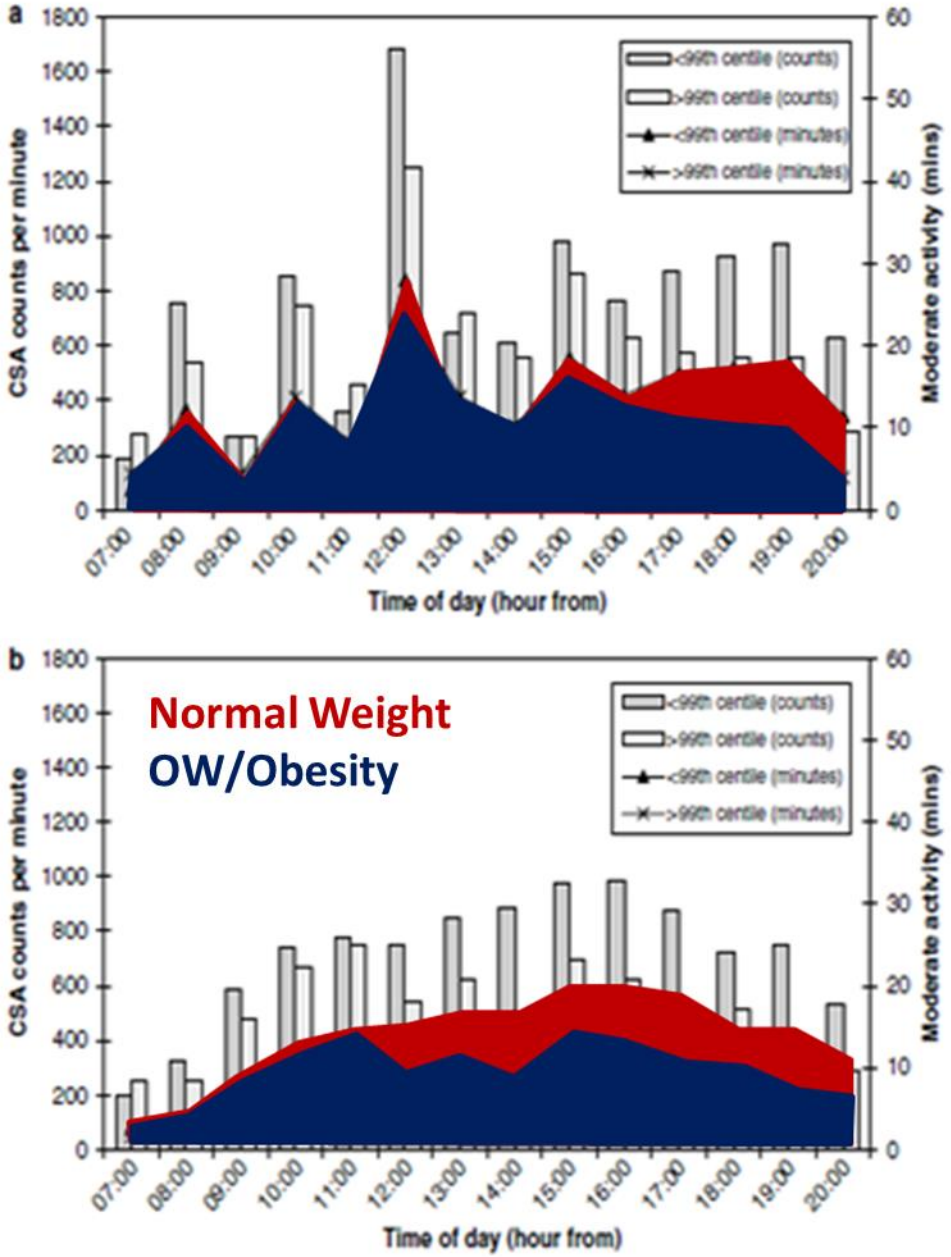
Age	Type	Frequency	Benefit
< 12 months 	Supervised play Safe environments (e.g. tummy time, games with siblings to encourage reaching, grasping, pulling and pushing.)	**Daily** for 5-15 min sessions.	Supports brain development. Builds strong bones and muscles. Improves movement and co-ordination skills. Promotes social skills.
1-5 years 	Supervised games promoting reaching, stretching, crawling, running, kicking, throwing and catching	**At least** 3hr/day (short bouts of 10-20 minutes)	Builds strong hearts, bones and muscles. Improves balance and co-ordination skills. Helps achieve and maintain a healthy weight. Encourage self-confidence and independence.

O'Malley G & Thivel D, 2016; ECOG EBook http://ebook.ecog-obesity.eu/

European Childhood Obesity Group

Age	Type	Frequency	Benefit
5-12 years 	MVPA With impacts to promote bone health (e.g. skipping, jumping, running & dancing).	**At least 60 min/day** **At least 3 days/week high impact**	Supports concentration and learning Builds strong bones and muscles. Improves movement and co-ordination skills Improves balance and co-ordination skills. Helps achieve and maintain a healthy weight. Encourage self-confidence and independence. Helps the child to make new friends and to Develop social skills.
13-17 years 	MVPA With impacts to promote bone health Active transportation Organised and non-organised sports games PE and other activities at home, school, work and in the community.	**At least 60 min/day** **At least 3 days/week high impact**	Supports concentration and learning Builds strong bones and muscles. Improves balance and co-ordination skills. Helps achieve and maintain a healthy weight. Encourage self-confidence and independence. Helps the child to make new friends and to develop social skills. Improve cardiometabolic health, Enhances mental health and wellbeing, Supports cardiorespiratory fitness

O'Malley G & Thivel D, 2016; ECOG EBook http://ebook.ecog-obesity.eu/



Page et al., 2005

Lower PA level

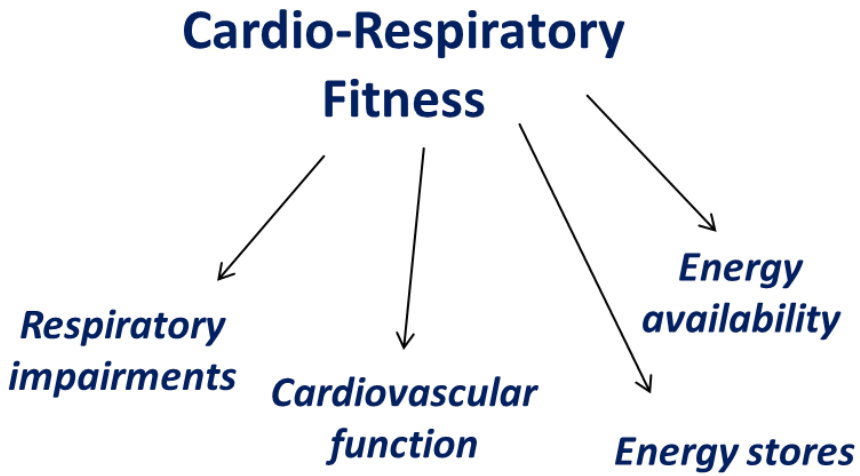
Sedentariness
Physical Inactivity

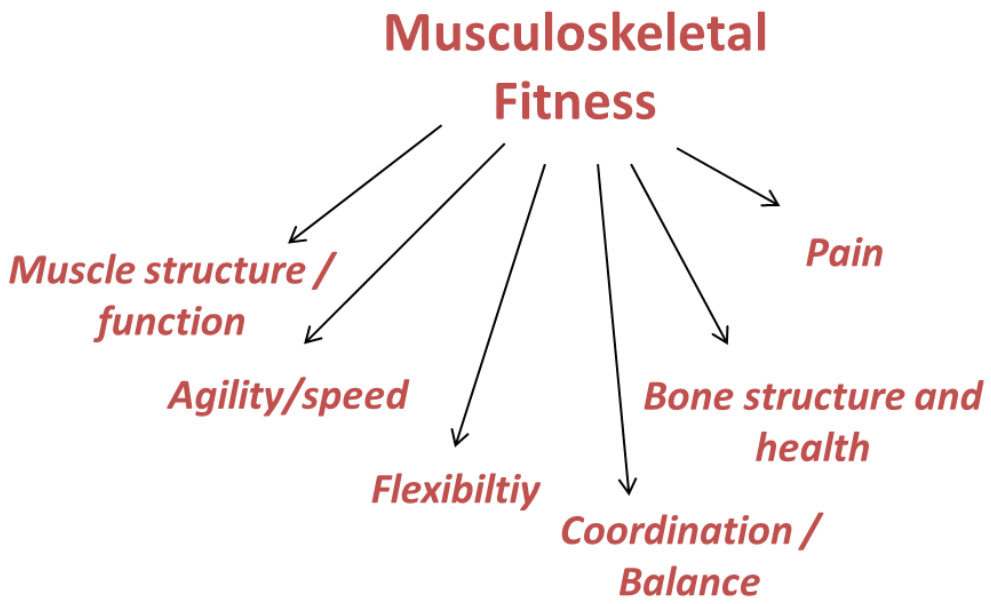
Lower Physical Fitness

↑ Perceived Exertion / ↓ engagement / ↑ drop out

Capacity to perform daily activities with no pain or excessive fatigue

Physical Fitness





O'Malley G & Thivel D, 2016; ECOG EBook

E-module from the European Childhood Obesity Group (ECOG) & the World Obesity Federation (WHO)

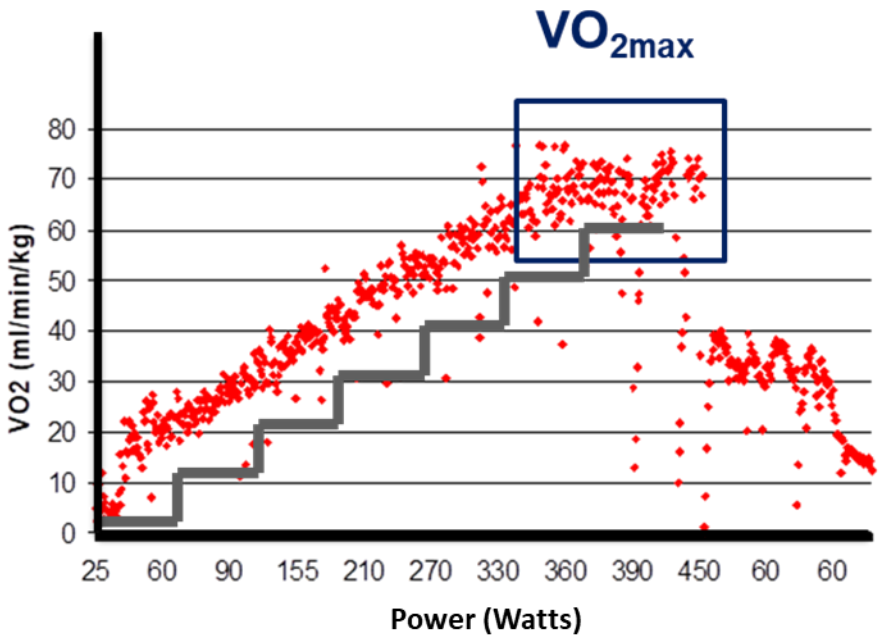
PART II

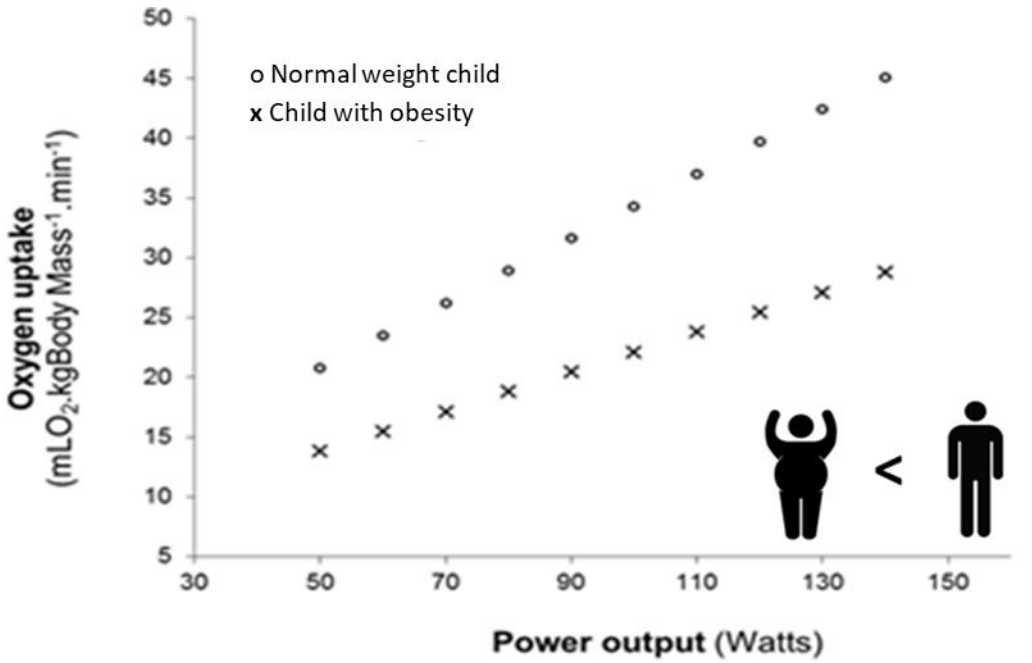
Physical Activity & Fitness in Pediatric Obesity:

Assessment of Physical Activity, Function & Fitness in Youth with Obesity

Grace O'Malley

Cardio-Respiratory Fitness





Thivel D & Aucouturier J, 2016; ECOG EBook http://ebook.ecog-obesity.eu/

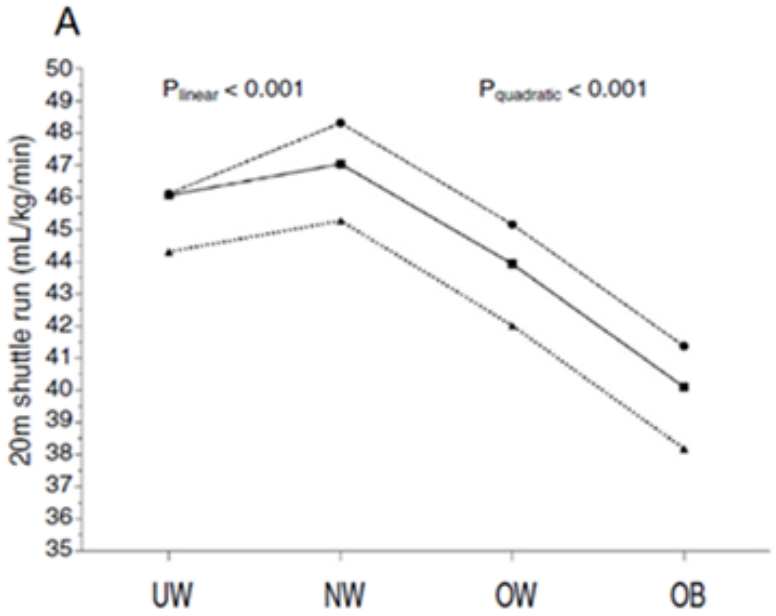
Cardio-Respiratory Fitness

Main limitations

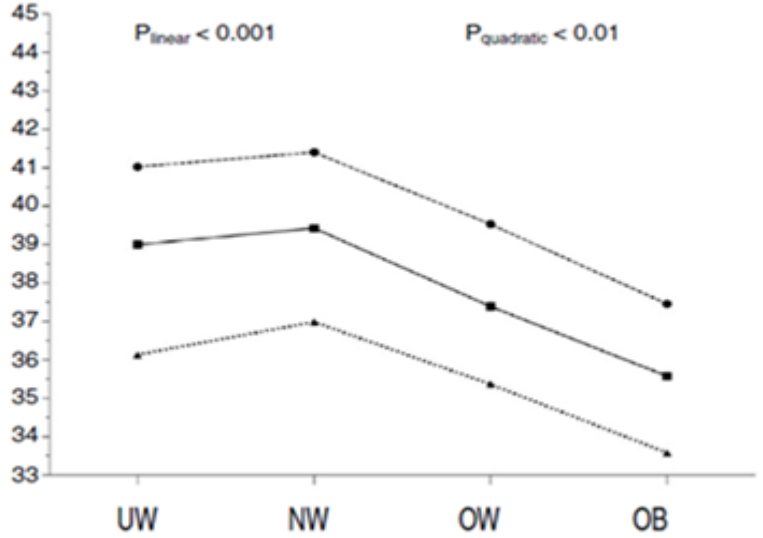
- Musculoskeletal pain
- Exacerbated perceived exertion

Main advantages

- Low cost
- Field tests easy to implement
- Several children/adolescents at a time



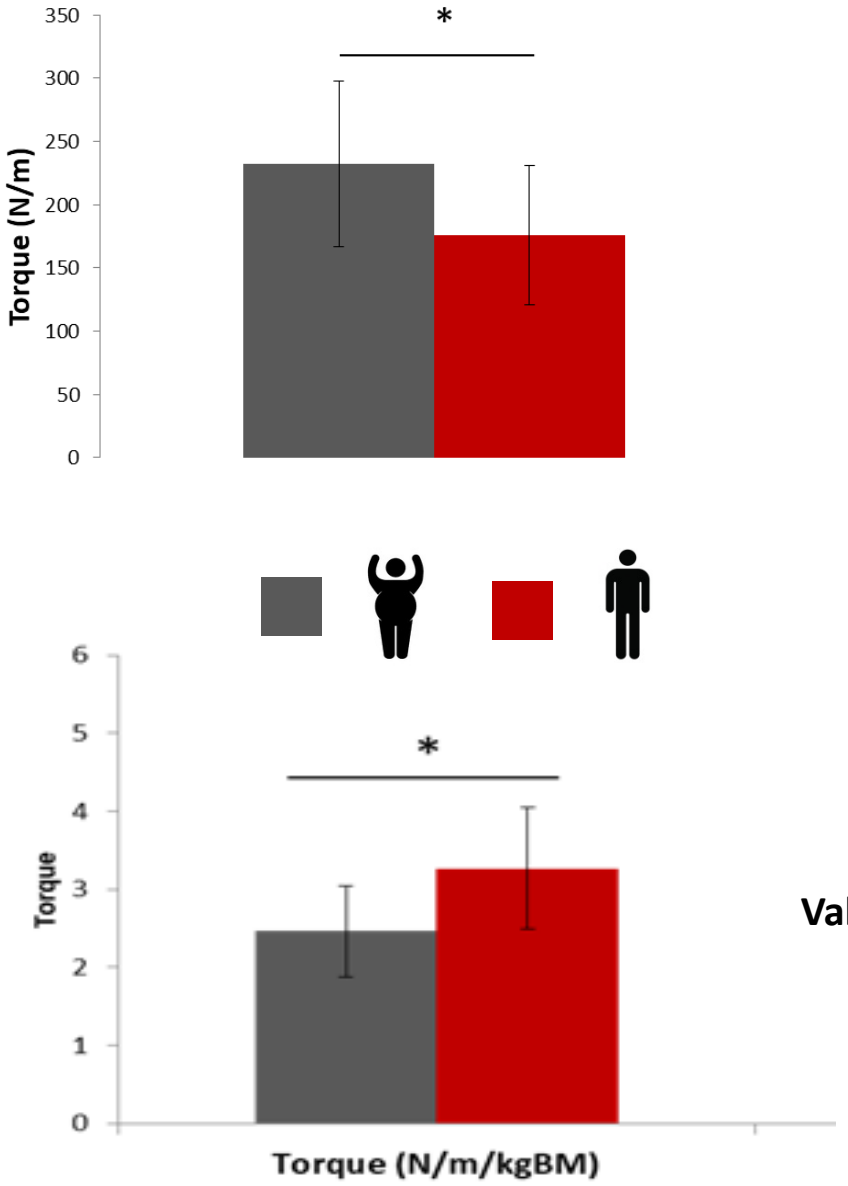
Boys



Girls

Garcia-Hermoso et al., 2018

Musculoskeletal Fitness

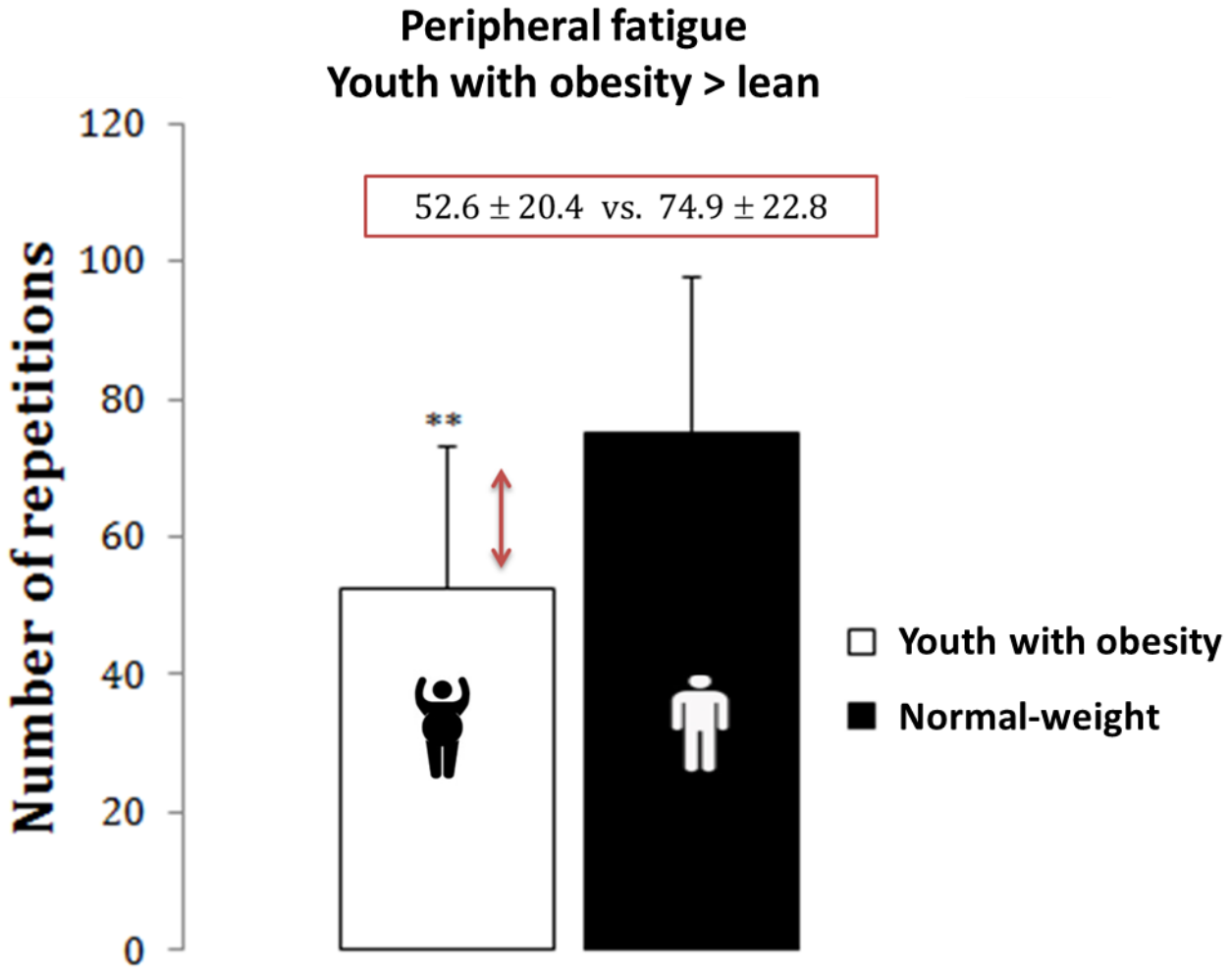


Absolute values

Values related to body weight

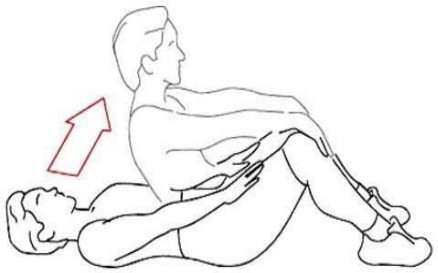
Abdelmoula et al., 2012

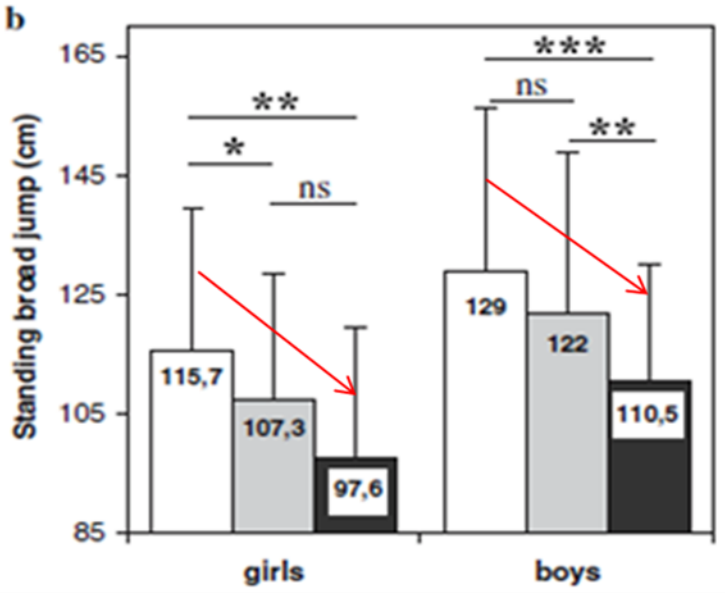
Musculoskeletal Fitness

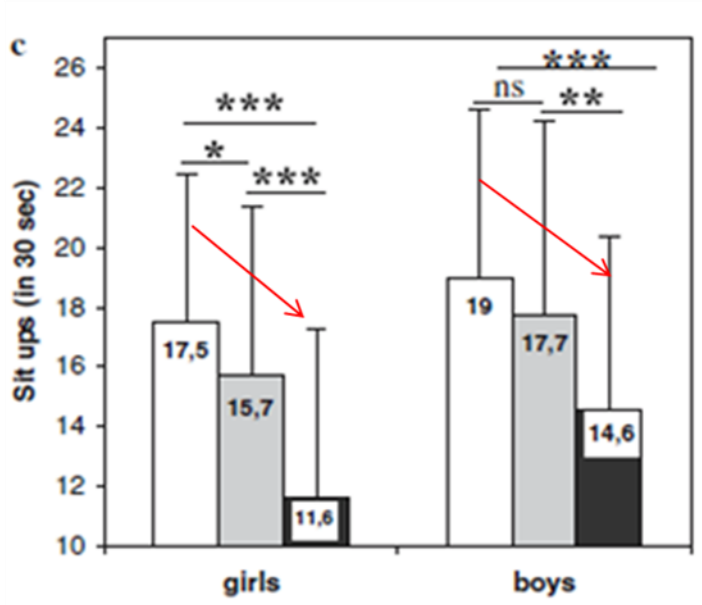


Vincenso Garcia et al., Int J Obes (Lond). 2016;40(2):245-51.

Musculoskeletal Fitness



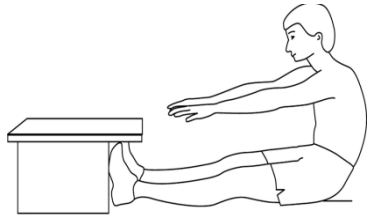


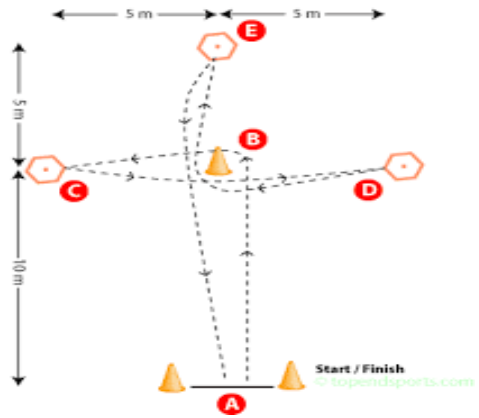


- Normal-weight
- Youth with OW
- Youth with OB

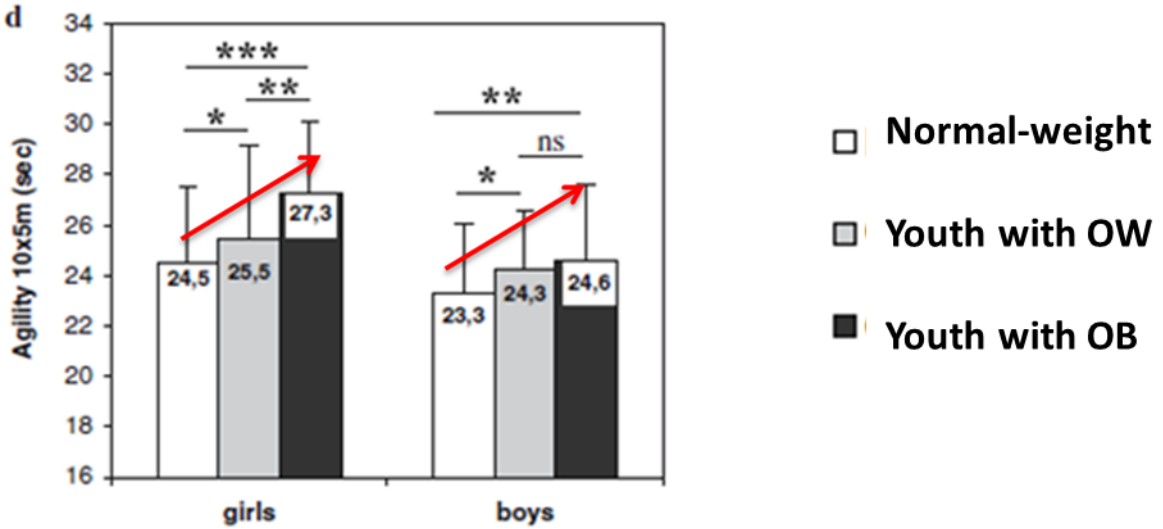
Tokmakidis et al., 2006
García-Hermoso, 2019

Musculoskeletal Fitness





	Class of age I			
	UW (*n*: 68)	NW (*n*: 434)	OW (*n*: 85)	OB (*n*: 39)
Endurance (s)	108.9 ± 22.5	116.0 ± 21.2	126.5 ± 17.3	147.4 ± 15.0*
Speed (s)	4.5 ± 0.6	4.6 ± 0.5	4.7 ± 0.4	4.8 ± 0.2*
Agility time (s)	24.1 ± 5.0	23.1 ± 4.6	25.1 ± 4.7*	27.7 ± 2.7*
Agility errors (n)	0.4 ± 0.1	0.4 ± 0.2	0.5 ± 0.2	0.6 ± 0.1*
Long jump (m)	0.95 ± 0.17	0.92 ± 0.20	0.86 ± 0.19	0.75 ± 0.10*
P_{max} ($W \cdot kg^{-1}$)	29.2 ± 4.8	31.5 ± 6.3	26.1 ± 3.2	24.0 ± 4.0*
Balance errors (n)	1.1 ± 0.5	1.1 ± 0.4	1.6 ± 0.7	2.0 ± 0.5*
Handgrip (N)	104.8 ± 22.5	110.1 ± 21.3	113.3 ± 25.5	118.0 ± 22.0
Throw back ball (m)	3.58 ± 1.17	3.66 ± 1.15	3.66 ± 1.10	3.78 ± 0.81
Flexibility (cm)	1.76 ± 1.36	2.47 ± 1.32	2.30 ± 1.31	1.22 ± 1.13

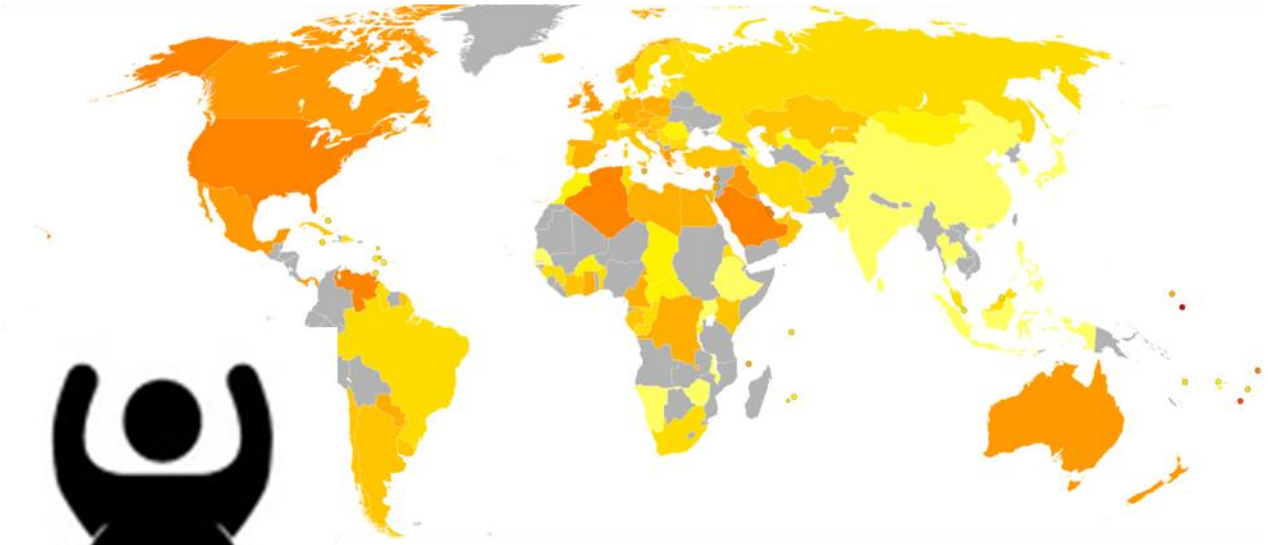


Tokmakidis et al., 2006; Ceschia et al., 2015

Orthopaedic Complications

Download Article

↓ PA Level → ↓ Physical fitness



↓ Impaired fitness

← ↓ PA Level

European Childhood Obesity Group

Take home message

International Journal of EXERCISE SCIENCE

Invited Editorial

Physical Activity and Physical Fitness in Pediatric Obesity: What are the First Steps for Clinicians? Expert Conclusion from the 2016 ECOG Workshop

GRACE O'MALLEY[1,2], SUSANNE RING-DIMITRIOU[2,3], PAULINA NOWICKA[2,11,12], ANDREA VANIA[2,13], MARIE-LAURE FRELUT[2,4], NATHALIE FARPOUR-LAMBERT[2,5], DANIEL WEGHUBER[2,6,7], and DAVID THIVEL[2,8,9,10]

First recommended clinical steps:

1. Estimate PA level
2. Identify barriers to PA and potential fitness impairments
3. **Encourage the family to meet age-appropriate PA guidelines**
4. Refer the child for exercise-testing and physiotherapy as appropriate

E-module from the European Childhood Obesity Group (ECOG) & the World Obesity Federation (WOF)

PART III

Physical Activity & Fitness in Pediatric Obesity:

Strategies to improve physical activity and fitness

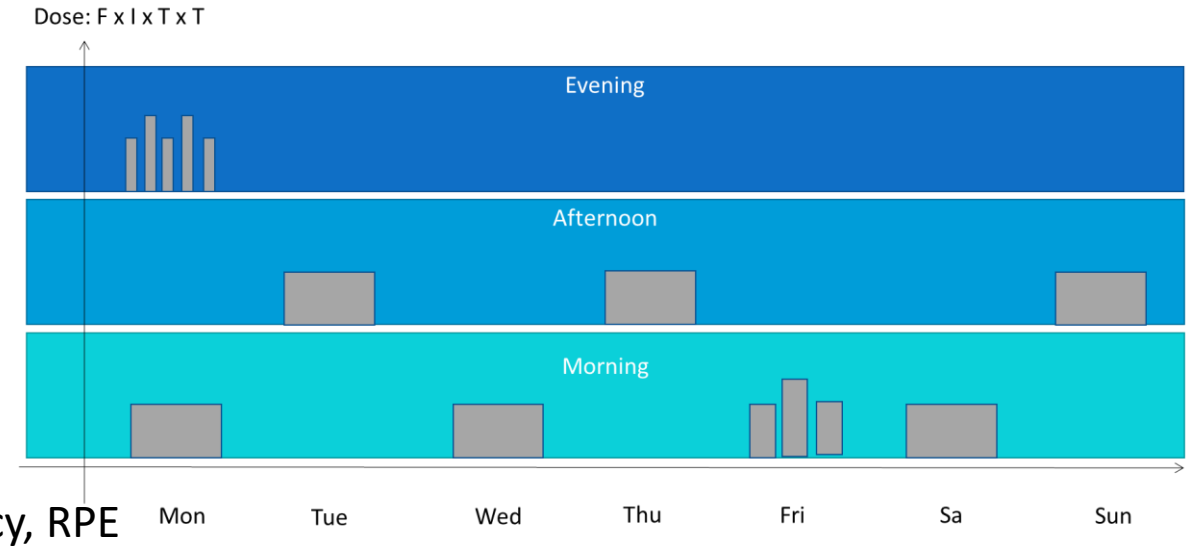
Susanne Ring-Dimitriou

Exercise Training Principles

- ***Individual centered***
  - Age, gender and health status appropriate
- ***Structured***
  - Goal setting (SMART) -> planned, systematic, regular; supervised
- ***Specific***
  - Type of Exercise: cardiorespiratory, muscle and bone strengthening
- ***Progressive***
  - Exercise loading via F.I.T.T.T.E principle (dosage)

Reid, Thivel & Mathieu (2019) and Brunet et al. (2019)

F.I.T.T.(T.E.) Principle



F Frequency

Number of exercise bouts per day within a week

I Intensity

External loading – Watt

Internal loading – increase in Heart Rate, breathing frequency, RPE

T Time

Duration of a specific game/exercise or the whole exercise bout

Time of an exercise repetition (e.g. 8 x squat)

T Type: intermittent, 30s rest

Ratio of loading vs. rest time (e.g. 60s : 30s): intermittent, continuous; **Energy consumption**: predominant aerobically, anaerobically

Motor ability: endurance, strength, speed/agility, flexibility and balance; **Body region:** lower body (legs) vs. upper body (arms and trunk)

Setting: Group game or individual game/exercise , outdoor or indoor;. supervised vs. not (home-based)

T Timing of exercise

Exercise prescribed at a specific time to optimize its effects (i.e. related to the meal for instance)

E Enjoyment

Exercise has to be fun for the child/teen in order to be adopted into daily life.

Effect of Exercise Intervention on Fundamental Movement Skills (FMS), Study 1

4 – 17y old; children classified as NW, OW and OB; 36wk-intervention

Table x. Reported Effects of Exercise on FMS-level in children with OW/OB (Han et al., 2018)

FMS, motor skills	FMS-tasks	Change in FMS
Locomotion	Jumping Running /agility (obstacle run)	+ +++
Object manipulation, object control	Throw, Hand Catch, Hand Kick, Leg	0 n. a. n. a.
Postural Control, Balance	One-leg stand (static) Balance bar (dynamic)	+ +

Note. +++ strong effect, + positive effect , 0 not clear, - negative effect; n.a. not available/not investigated

Han et al., 2018

Interpretation

The tested / evaluated motor task has to be

- *included in the exercise program!*
- *a goal-oriented movement (throwing a ball into the basket, kicking a ball into the goal…)*
- *addressed specifically (one task) and repetitively (one task from low -to high difficulty level) to generate an increase in FMS-level.*

Playing a game (soccer) or engagement in an obstacle course addressing various motor skills will be less effective.

Effect of Exercise Training on Physical Fitness
Study 2

11-13y old; Boys with OW and OB; 12 wk-program: **F**=5x/wk (2xPE + 3x Soccer or 3x HIIT) , **I/T**=HIIT, **T**=60,

Table x. 12-wk change (%) in motor ability level of OW or OB boys (Cvetkovic et al., 2018)

Outcomes	Abilities	Football +PE, FBG vs. PEG	HIIT+PE, HIG vs. PEG
Strength	Leg Strength, Jump (CMJ)	n.s.; n.s.	n.s.; n.s.
Speed	Agility, t-Test Sprint Run	++; n.s.	++; n.s.
Endurance (CRF)	Yo-Yo intermittent run (2x 20m) Heart Rate, rest (HR-rest)	++; + ++; ++	++; + ++;++

Note. CRF = cardio respiratory fitness; n.s. not significant pre vs. post (within-group) or between intervention (football group FBG, high intensity group HIG) and control group (physical education group PEG; between group); ++, *P* <.01; +, *P* <.05;

Interpretation

*Additional Football or High Intensity Interval Training (HIIT), 3x 60min/wk, combined with to 2x 60min/wk PE in School significantly maintains body mass and **increases** significantly **cardio-respiratory fitness** compare to a control group (PE only).*

Leg strength and agility performance level improved slightly in both intervention groups. No significant difference was found between groups.

*Again: **Specificity** is important in exercise training to achieve substantial effects in motor ability components.*

Cvetkovic et al., 2018

Effect of Resistance vs. Aerobic Training on Health Outcomes Study 3

11-18y old; Boys, Girls with OW and OB; 10-48 wk-program:
F=2 to 3x/wk, I=aerobic vs. resistance, T=20-60 min/session, T=concurrent (AT + RT)

Table x. 10- to 48-wk change (%) in motor ability level of OW or OB youth (Garcia-Hermoso et al., 2018)

Health outcomes	CE (RT + AT) vs. AT only
Body Mass, kg Fat Mass, kg Lean Body Mass, kg	+, decrease ++, decrease +, increase
LDL, mg/dL HDL, mg/dL Total Cholesterol, mg/dL	++, decrease 0 0
Adiponectin, µg/mL	+++, increase
Fasting glucose Fasting insulin HOMA	0 0 0

Interpretation

Long-term concurrent exercise training, i.e. a combination of resistance and aerobic exercise over 60 min per day and over at least 24 wks, improved the metabolic profile significantly in adolescents who were overweight/obese.

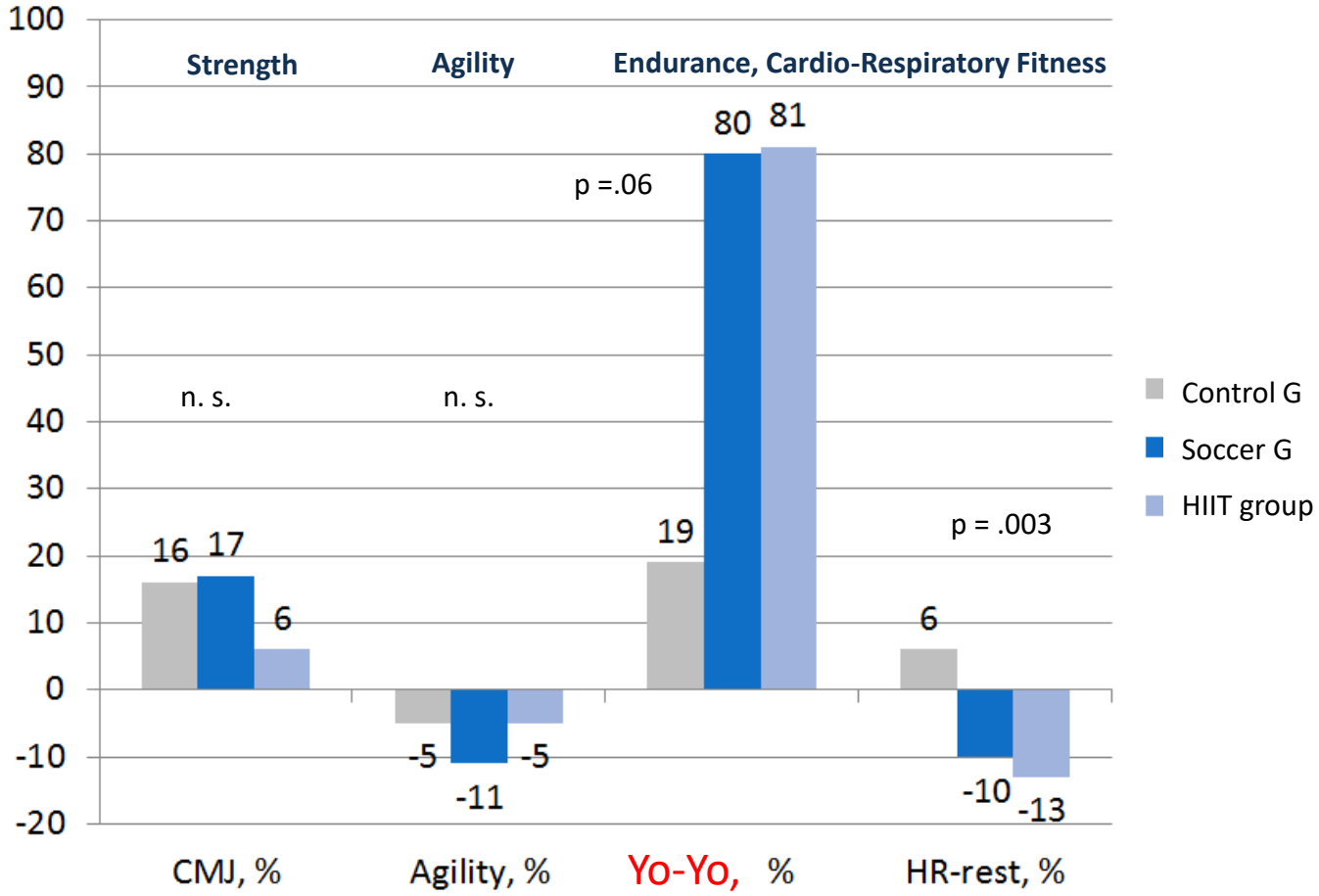
Again: supervised and structured sessions consisting of work loads affecting energy metabolism result in favourable improvements in body composition and, as demonstrated in that meta-analysis, in metabolic indicators.

Garcia-Hermoso et al., 2018

Note. AT, aerobic training; CE = concurrent exercise, resistance (RT) + aerobic (AT) exercise training; positve change in CE vs. AT: +++, $P \leq .001$; ++, $P \leq .01$; +, $P \leq .05$; 0, n.s.

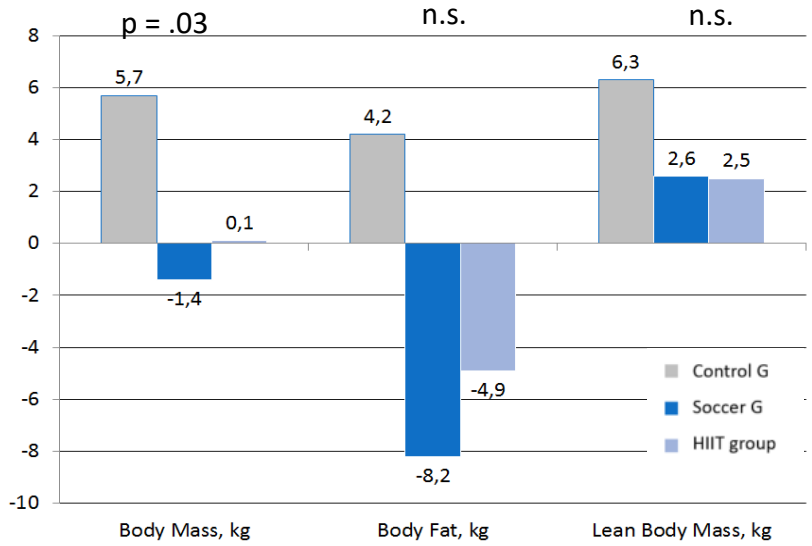
Effect of Exercise Training on Physical Fitness
Study 2

11-13y old; Boys with OW and OB; 12 wk-program: F=5x/wk exercise , I/T=HIIT, T=60 min



Body Composition

InBody



Note: modified by Ring-Dimitriou based on reported data by Cvetkovic et al. (2018), exercise-induced 12-week changes (%)

Take home message

Favourable effects of exercise training on motor skills, abilities and health-related physical fitness in children with OW and OB are guaranteed if:

- The exercise principles “Supervised, structured and specific” are utilized. Post-effects in most of the cases occur. This is a good buy in treatment!

- *In preschool and school-age*: Goal-oriented tasks, as FMS or sports games, improve motor skill level as a prerequisite of engagement in PA, play and sport activities; they are feasible and generate joyful experiences.

- *In youth*: a combination of aerobic and resistance training improve physical fitness and body composition.

References

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Questions

1. What is physical inactivity?

- ❑ The total absence of physical activity
- ❑ The amount of sedentary behaviour
- ❑ Failing to reach age-specific physical activity recommendations

2. What is the main PA recommendation for youth 5-18 years old?

- ❑ 60 min / day of moderate-to-vigorous physical activity
- ❑ 1 hour of activity 3 times a week
- ❑ 3 hours / day of physical activity

3. What is physical fitness?

- ❑ The capacity to perform daily activities without pain or excessive fatigue
- ❑ Meeting the physical activity recommendations
- ❑ Accumulating less than 2 hours of screen time / day

Questions

4. What are the two main components of fitness

- ❑ Body Mass index
- ❑ Cardio-respiratory
- ❑ Musculoskeletal

5. What are the main principles of exercise interventions?

- ❑ Structured / Specific
- ❑ Progressive / Individualized
- ❑ Group-based
- ❑ Inpatient / outpatient

6. What is the main component of daily energy expenditure?

- ❑ Thermic effect of food
- ❑ Physical fitness
- ❑ Meeting physical activity recommendations
- ❑ Resting energy expenditure

Thank you!

For more information

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